REPORTING EXPENDITURES FOR POLLUTION ABATEMENT FACILITIES--A CASE STUDY IN SOCIAL RESPONSIBILITY ACCOUNTING

By

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DEDICATED

TO MY BEAUTIFUL WIFE

PATRICIA

AND

MY TWO BEAUTIFUL SONS

STEVAN DEAN AND SHANE DOUGLAS

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Modern technology of industrialized societies has provided the highest standard of living for the greatest number of people in the history of mankind. These productive capabilities have also produced negative impacts upon the physical environment to the extent that man's very survival may be threatened. These external diseconomies from business entity operations occur because air and water are utilized as repositories of industrial wastes. The market mechanism is imperfect in that it does not provide incentives to minimize the undesirable impacts upon these "free" factors of production nor does it compensate individuals adversely affected by the entity's operations.

Society has responded to this state of affairs by imposing legislative constraints upon certain business activities. Some of these constraints have forced a number of businesses out of existence, thereby depriving society of the positive aspects of their operations. This changing cultural environment presents new challenges to business communication devices.

The present financial accounting reporting model reports the results

of recognizing, recording, and summarizing economic events with no consideration given to the other entity activities desired by society. The results of these activities are discussed in stockholders' reports in the president's and/or chairman's letters and/or somewhere in the narrative section of the report preceding the financial statements.

Businessmen have expressed a need for a more comprehensive communication device that portrays entity efforts and accomplishments over a broader range of the firm's activities. This will enable the businessman to respond to critics and hopefully stem the tide of unfavorable legislative constraints.

Accountants and various units of the accounting profession have stipulated that developing indicators of social performance for business entities is a legitimate extension of the accounting function. To date, however, no operational expanded accounting reporting model has been formulated for utilization by business.

This research project has developed such a proposed expanded accounting reporting model encompassing a supplemental Environmental Impact Report. This report narrates the entity's pollution problems and efforts, expended and planned, to deal with these problems. Schedules of expenditures (efforts) for pollution abatement facility acquisition and operation for the most recent five years would be included along with schedules of estimated pollutants produced by the firm's operations. Also, the traditional statement of financial position would be expanded to show social investments in pollution abatement facilities as separate items and the traditional income statement would be expanded to show social depreciation and social operating costs as separate items. It is expected that, as substantial social investments are made in pollution abatement

facilities (efforts) the negative impact of the entity's activities upon the physical environment would be reduced to acceptable standards (accomplishments).

This proposed expanded accounting reporting model would provide a formally structured communication device for portraying business entity's recognition of, and efforts to forcefully respond to, its social responsibilities in the area of protecting the environment. This would be in addition to the traditional financial data for evaluating the firm's economic performance. The proposed expanded accounting reporting model has the advantage of being immediately operational utilizing existing measurement and reporting capabilities. Another advantage is that quantities in the report could be subjected to attestation procedures by outside auditors. The model offers possibilities of being expanded into additional areas of social activities of the firm as improved measurements and reporting techniques are developed.

The contribution of the dissertation is the demonstration of a case study of an actual operating entity in an industry well known for its pollution effects. In the study the methodology for recognizing, recording, summarizing, and reporting expenditures for social purposes and the development and presentation of the proposed expanded accounting reporting model will be illustrated.

CHAPTER I

THE NEED FOR AN EXPANDED ACCOUNTING REPORTING MODEL

Rapid Rise to Abundance

The Industrial Revolution, which began in the late 1700s, virtually exploded western civilization into an era of abundance compared to the struggle for survival that had been man's plight for most of his span of existence upon the earth. The rapid rise in manufacturing was engendered by a cultural environment which encouraged the accumulation of the necessary large capital investments, expanded monetary systems, developed transportation systems increasing marketing capabilities and provided general conditions of stability for the most part. The swift increase in agricultural productivity freed a substantial majority of the work force to shift to satisfy ever rising demands for labor in manufacturing and other types of commercial endeavors.

Economic activities culminating in the abundance of goods and services presently available in advanced industrialized societies are the result of some combination of the productive factors: land, labor, and capital. The considerations paid to the factor owners represent their income which is utilized to acquire the output of the economic process via the price/market mechanism. Income in excess of that necessary to satisfy the physical needs of the factor owners are utilized in various ways. A substantial portion is taxed away to support governmental activities at the various levels. Some is channeled into supporting diverse

cultural activities directly. The remaining savings from income provides the additional capital necessary for expanding industrial output. Gaskill makes the point that "business can be regarded as a fulcrum that provides the material means necessary for the activities of these other institutions (education, government, the church, etc.) and the new institutions that may be needed to solve vast public problems. All must be fueled by the wealth producing capacity of the business sector."[1]

Criticism of Economic Activities

If all factors are compensated in accordance with their contribution to the productive process, then all should be well in those countries enjoying highly industrialized economic activity. Mounting criticism of the business sector of society, particularly in the United States, clearly indicates that there is much dissatisfaction with the goose that lays the golden eggs. As might be expected, the great majority of the criticisms of business activities comes from individuals outside the business community. This places them in the contradictory position of criticizing the institution upon which they depend for existence. Such is the affordable luxury of an extremely wealthy society such as ours.

These criticisms are directed at many aspects of economic activities. Recently some of the loudest and most effective, in terms of bringing about change, have been in the area of pollution or the negative physical impact upon the environment wrought by many businesses, particularly manufacturing concerns. Society has reacted to the situation by enacting legislative constraints upon business functions. As a result, some economic entities have been forced out of existence, thereby depriving society of the positive benefits of their operations.

Weakness of Traditional Financial Accounting Reporting Model

The traditional financial accounting reporting model used by business entities has been ineffective in communicating forcefully the businessman's recognition of his social responsibilities in the area of protecting the environment. The end product of this research project will be an expanded accounting reporting model which displays in the traditional financial statements social expenditures made to acquire and operate pollution abatement facilities. A suggested supplemental Environmental Impact Report will also be included in the annual report to outsiders. This report will narrate the entity's pollution problems and efforts, expended and planned, to solve these problems. The recommended report will display a 5-year presentation of capital and operating expenditures made for pollution facilities (efforts) and actual or estimated quantities of the various pollutants flowing from the productive processes. The supposition is made that significant expenditures for acquisition and operation of pollution abatement facilities will be accompanied by substantial reductions in the negative environmental impact of the firm (accomplishments).

The expanded accounting reporting model should communicate to interested parties the entity's recognition of, and attempts to meet, its social responsibilities in the area of pollution. The contribution of the research project will be the demonstration of the methodology for recognizing, recording, summarizing, and reporting both efforts and accomplishments of businesses in this socially desirable area of their activities. Hopefully this will assist in stemming the tide of hastily imposed legislative constraints against business and help to engender a

cultural environment conducive to maximizing the positive benefits of economic activities while at the same time providing adequate protection to the physical environment.

The method to be utilized in reaching the objectives of this research project will be a case study of an existing manufacturing plant having a substantial negative impact upon the environment. Pollution points in the productive processes will be identified. Estimates of pollutants produced by the plant will be made for the most recent 5 years. Investments in pollution abatement facilities and the operating costs of these facilities will be determined in order that they may be classified as social expenditures. These dollar amounts will also be gathered for the most recent 5-year period in order that they may be presented in the Environmental Impact Report. The determination will also be made as to whether the plant is in conformity with existing pollution standards.

At this point it is considered necessary to present a more thorough analysis of the following: (a) factors leading to the disillusion of many in society with some aspects of economic activities; (b) the nature and significance of pollution; (c) the changing cultural environment in which business must function; and (d) the need for communicating the social efforts and accomplishments of business enterprises.

Social Cost--Area of Ambiguity

Before proceeding with our discussion of the significance of pollution as a social cost imposed upon society by business economic activity, it may be well to pause and clarify the meaning of this phrase within the framework of this paper.

Cost is an accounting concept representing the expenditures (efforts)

necessary to provide a desired end product and has important significance at the firm level. The difficulty is that discussions of the problem of pollution are many times phrased in terms of "social cost accounting," "social responsibility accounting," or simply "social accounting."

Social accounting has been referred to as another name for national income accounting. In this area of accounting the value of all goods and services produced at the micro level are aggregated to produce the gross national product (GNP) for a period of time.

David Linowes[2] refers to "socioeconomic accounting" when he discusses the application of accounting and business expertise to the development and administration of public programs designed to solve cultural problems. Performing this function would enable businessmen and accountants to meet their social responsibilities. The implication is a form of social responsibility accounting.

Neither the national income accounting nor the application of accounting and business expertise to public programs falls within the realm of social accounting as envisioned in this paper. Later we will explore more thoroughly the need to account for social responsibilities of business firms and the difficulties in meeting this need within the structure of the present accounting model.

The Social Cost of "Free" Factors of Production

The Classical "Free" Factors of Production

As noted above, the prices paid for the output of the economic process represent income to the owners of the factors engaged in its production. No return or an inadequate return to a factor could result in its withdrawal from the productive activity in the long run provided

the factor itself is subject to property rights supported by society. A significant part of the problem of contemporary industrialized societies is the utilization, in the productive processes, of factors which are not subject to individual ownership rights and hence capable of demanding compensation for their use. The "free" agents of production are air and water which are the province of all of society.

Air and water are important to the operations of industrialized economies as they serve as receptacles for the wastes culminating from the production and consumption functions. Kneese, Ayres and d'Arge note that "the ability of the natural environment to receive and assimilate (wastes) is an important natural resource of rapidly increasing value."[3] If the deposit of wastes into the atmosphere or waterways produces discomfort to individuals downwind or downstream from the productive facility, there is no mechanism, as Friedman[4] observes, for individuals to force compensation from the business entity for the exchange of good air or water for bad. Also, since no costs are incurred in the utilization of the free agents in the productive process, the prices received for the goods or services produced need not cover the expenditures necessary to negate or minimize the undesirable impact of economic activities upon the physical environment.

External Diseconomies--A Redistribution of Income

Estes defines external diseconomies as "the damages, or negative effects, inflicted on outsiders by activities of an entity which are not recognized explicitly as costs by that entity, and for which the outsiders are not adequately compensated. The most obvious forms of external diseconomies . . . are the various forms of pollution."[5] Dworsky defines

pollution as "an undesirable change in the physical, chemical, or biological characteristics of our air, land, and water that may or will harmfully affect human life or that of other desirable species, our industrial processes, living conditions, and cultural assets; or that may or will waste or deteriorate our raw material resources. Pollutants are the residues of the things we make, use, and throw away."[6]

External diseconomies are broadly referred to as the social costs of economic activities which originate from an imperfect market mechanism which fails to compensate adversely affected individuals for undesirable effects of business operations nor requires the elimination or reduction to acceptable levels of these negative effects. Beams and Fertig characterize pollution as "a type of income redistribution from citizens and taxpayers to the customers and investors of the polluting firm."[7] An equally significant impact of the failure of private costs to equal social costs is the overstatement of the returns to the factors engaged in certain economic activities. Such an occurrence could attract additional scarce resources to those activities having the highest social costs to society as a whole. The result is a possible misallocation of scarce resources from desirable activities to undesirable ones.

Factors, other than pollution, that have contributed to complaints and, in some instances, to restrictive legislation are: discrimination in hiring and promoting certain groups of individuals; other unfair labor practices; deliberate attempts to eliminate competition; unfavorable pricing policies for certain classes of customers; price gouging and excessive profits from certain unusual circumstances; and distortions, omissions, or deliberate misrepresentations in reports to outsiders. Further discussion of all of these other factors contributing to society's

unfavorable reaction to business practices are outside the scope of this research project.

How Significant is Pollution?

A Nuisance or a Threat?

In the previous discussion of pollution we noted in the definition that it constitutes an undesirable change in our physical environment that may be detrimental to living things or harmful to resources.

An example of the substantial damage that can be inflicted upon a natural resource is noted by Savin who states that "Lake Erie is a localized example of what can happen to a large body of water. Almost a closed ecosystem, the lake has been classified by some groups as technically 'dead'--unable to support life processes because large quantities of organic industrial waste and municipal sewage altered the ecological balance."[8] Hill observed the loss of a thriving multi-million dollar fishing industry as a result of the pollution of Lake Erie.[9] He also comments upon the enormity of the expenditures required to bring the pollution of this resource to tolerable levels. "It will cost upward of $100 million just to bring Detroit's sewage system up to standard. The outlay confronting industry there for adequate waste treatment facilities is probably several times that. Along the whole lakeshore, comprehensive remedial measures will probably run into the billions."[10] Hill also notes that even if the flow of wastes into Lake Erie were stopped, scientists are not certain that it could be restored to its former state. Some encouragement for restoring polluted resources may be gained from an article by Cook[11] where he discusses the rebirth of the polluted Ruritan River in New Jersey largely through the efforts of the area's

leading businessmen.

A much more important aspect of the pollution problem is its effect upon the physical wellbeing of people. Minor physical discomforts may be experienced from the odor of a kraft paper mill when the wind blows from a certain direction. A more forceful impact might be the stinging sensation in the eyes when a temperature inversion prohibits the carrying away of air pollution by the air currents. Such discomfort might last for several days. Goldman[12] cites examples of illnesses and deaths (Donora, Penn. - 1948; London - 1952 and 1953; and New York - 1963) directly traced to air pollution. Griffin presents an even more forceful condemnation when he cites the chairman of a panel of medical experts at a National Conference on Air Pollution Control who stated that "The evidence that air pollution contributes to the pathogenesis of chronic respiratory diseases is overwhelming . . . Beyond reasonable doubt, air pollution, like cigarettes, puts thousands of Americans into premature graves every year."[13]

That air pollution can render an area uninhabitable (Los Angeles?) was evidenced when it was observed that "Knapsack, a community of 2,500 persons near Cologne (Germany) . . . is being evacuated. Emissions from the four industrial combines in the area have become too unpleasant to bear."[14] Kapp[15] discusses this problem of industrial concentration for an area much closer to home--Donora, Pennsylvania. Vicker[16] enumerates the international scope of the pollution problem and its threat to the fishing industry in the North Sea, the state of the Baltic and Adriatic Seas, and predictions of the death of all sea life in 25 years if worldwide pollution continues.

A Question of Survival?

The utter completeness of the potential devastation from man's assault upon the environment may be seen in Rachel Carson's book, Silent Spring. She states that "In this now universal contamination of the environment, chemicals are the sinister and little-recognized partners of radiation in changing the very nature of the world--the very nature of its life."[17] Citing numerous instances of devastation and death for all forms of life as a result of the widespread use of man-made pesticides, and the existence in all living things of various quantities of these chemicals, Ms. Carson paints a dismal picture for mankind if their continued use goes unabated.

The strongest statement concerning survival is by Goldman and Shoop who note that "There is some fear among the more pessimistic scientists that the earth's natural balance has already been thrown off. Among other effects, this could cause an increase in the earth's temperatures of about one degree which could result in the advance of deserts and the inundation of coastal areas as icebergs begin to melt."[18]

The previous discussions leave little doubt that man's economic activities have had a tremendous negative impact upon his physical environment. Economic activities have destroyed resources and caused serious problems and deaths to thousands of people. Additional damage has been caused to crops, livestock, production equipment, and buildings, as noted by Griffin.[19] We need now to turn our attention to exploring the force of this phenomenon upon the cultural environment in which business must operate.

A Changing Cultural Environment

Profits vs. Survival

Until very recently business entities operated with relatively few constraints in terms of the negative physical impact of their activities upon the environment. The firm gathered together factors of production in some combination that would provide the good or service for the market with maximum returns to the factors of production. Expenditures for the productive process met the test of cost-benefit analysis which meant that only those costs necessary to produce the firm's output were made. Outlays for facilities to recover wastes from the productive process met the test of economics by providing recaptured materials and were not made as a result of concern with the environment. Other facilities to eliminate waste elements from production were necessary for the safety of the work force. Maximum use was made of the free agents of production, air and water, as depositories of industrial residuals.

"Economist Milton Friedman . . . still argues that the corporation's responsibility is to produce profits and that the cost of corporate social goals amounts to a hidden tax on workers, customers, and shareholders."[20] This, of course, is in direct opposition to previous comments that profits are excessive to the extent that the "full" cost of production is understated as a result of the failure of the firm to minimize its adverse physical impact upon the environment. The social goal of pollution control will result in full costing of a firm's output and a corresponding reduction or elimination of the income redistribution effect of pollutants flowing from the firm's activities.

Prince speaks of the contrast of short-run goals as possible threats to the long-run survival of the firm when he states that "Mathematically

the long-run is the summation of the many short-term periods. It is possible that for a given short term one might maximize what he thinks to be income only to the detriment of the continued profitability of the firm; in other words, long-term survival was not considered in relation to the present actions."[21] Dawson makes the point that "the firm concerned only with profit performance may find its lack of other internal or external social purpose to be a growing threat to its survival in an increasingly humanistic world."[22]

End of the Era of Permissiveness

Business entities have contributed significantly to pollution in their productive operations. The thrust of the activities of many firms is the result of decisions which fail to consider noneconomic factors. This narrow decision model may reflect a lack of perception of rising currents of change in society. Trueblood makes the observation that "The great majority of businessmen and professionals today consider themselves decent and honest by any reasonable measures. Yet, when it comes to specific decisions or actions, many seem insensitive to the temper of our time."[23] As a result of this failure to perceive the depth of the change emerging from the cultural environment and responding to it positively, business has come under attack from all angles, as previously noted. Miller describes this force when he states that "we businessmen . . . feel insecure and under attack from many directions. . . . We are under attack from government at every level--increased taxes, increased laws, increased regulations, increased interferences . . . We are attacked by our children . . . by the church . . . by the very nations we have helped most . . . by racial minorities. There seems to be no end to the list."[24]

Individuals, as has been previously stated, stand little chance of influencing the conduct of large business entities. It is only through their collective efforts embodied in legislative institutions that they can wield an element of social control over these entities. Bowen notes that "Just as society can establish and enforce standards of right and wrong in matters of personal etiquette, dress, family relationships, language, religion, and a host of other aspects of life, so it can establish and enforce standards of right and wrong in matters of business operations."[25] While the legislative process offers hope for the correction of many social ills, it may also provide potential unworkable constraints upon business entities. If this occurs, society stands to lose the positive benefits of firms that are forced to cease operations because of legislative restrictions.

Two examples of the above phenomenon are the closing of an American Smelting & Refining Company zinc smelter in Amarillo, Texas, because of the "inability to cope with the high cost of pollution control,"[26] and the Goodyear Tire & Rubber Company polyvinyl-chloride-resin plant at Niagara Falls, New York, "because 'it was economically unfeasible' to meet federal standards on workers' exposure to the chemical."[27] The president of Asarco cites potential multiplier effects of the plants' closing unless the state will permit it to operate until the federal deadline of June 30, 1975, for air pollution control standards. He states that "if our Amarillo plant is shut down before replacement capacity comes on steam, the 50,000 tons per year of refined zinc produced at Amarillo will have to be imported at an increase in the already critical balance of payments deficit."[28] He continues by stating that "unless a new smelter was built before the old one was closed, the mines that feed

the smelter won't have any place to process their ore."[29] These potential adverse economic effects would be in addition to the loss of jobs for the 450 employees of the plant. Additional cases of plant closings because of pollution laws could be cited but this is not considered necessary. In contrast, "marginal business organizations that simply can't afford the (pollution abatement) equipment"[30] are allowed to continue to pollute the Ruhr River in Germany where industry and municipalities have combined to form "river associations" to protect water resources.

There is little doubt that a substantial change has occurred and is continuing to occur in the cultural environment in which business entities must operate. No longer is it acceptable for businesses to relentlessly pursue profits with little or no regard for the external diseconomies produced by their activities. Society requires that businesses include certain desirable criteria and constraints, many of which have the force of law, in their planning and operating decision models.

The Need for an Expanded Accounting Reporting Model

The Traditional Reporting Model

Business entities have long communicated the economic aspects of their activities in the form of accounting reports. Statements of financial position, income statements, statements of changes in retained earnings and financial position and appended notes all reflect the culmination of the accounting process. The figures included in these financial statements portray transactions recorded at cost, summarized and reported in accordance with generally accepted accounting principles.

The traditional reporting model has for some time been criticized

for certain shortcomings. Historical costs which fail to consider current values, the changing value of the recording unit, the dollar, and the lack of comparability due to several acceptable methods for accounting for certain transactions are but a few of the older, more significant deficiencies. A more recent criticism of the traditional reporting model condemns its failure to indicate the firm's efforts to conduct its activities in a socially responsible manner. Andrews notes that "as the social role of business expands, the time honored standards of corporate performance have come into growing disrepute. Businessmen and their critics alike increasingly agree that the concepts of growth and profit as measured by traditional balance sheets and profit and loss statements are too narrow to reflect what many modern corporations are trying to do."[31]

Many firms have limited their efforts to communicate the recognition of social responsibilities and endeavors to meet them to: (a) pronouncements in press releases; (b) speeches by corporate officials; (c) comments in the president's and/or chairman's letters in the stockholders' report; or (d) comments in the narrative section of the stockholders' report. Generally all, or some combination of the above, are utilized. Stabler observed that "it's a rare chairman or president of a major company these days who hasn't, in speeches or in messages to stockholders, committed his company to social goals as well as economic ones."[32]

A review of stockholder reports would verify some of the assertions above and possibly give an indication of the number of firms that mention social expenditures. A much more efficient method of doing this, however, is to study recent issues of Accounting Trends & Techniques which is an

annual survey of accounting practices followed in 600 stockholders' reports prepared by the American Institute of Certified Public Accountants. The 1974 issue, which is a study of the 1973 stockholder reports, has a section entitled "Social Awareness Expenditures"[33] which presents a table of the number of companies making expenditures for aid to education, aid to minority groups, etc. The table also indicates that 80 of the 600 company reports studied disclosed expenditures for these purposes. Excerpts from 9 stockholder reports narrating corporate activities in this area were presented under such captions as "Public Responsibility," "Public Concerns," and "Public Interest Report."[34] Eight of these excerpts came from the narrative section and one came from the president's letter, both of which precede the formal financial statements in the stockholders' report. Two of the 9 excerpts related to environmental problems only one of which presented dollar expenditures.

The discussion above indicates that at present business entities do not have a formal reporting device for communicating efforts to respond effectively to social responsibilities. Attention will now be directed to ascertaining if such a need exists.

Will Expanded Formal Reporting Models be Forthcoming?

Previous comments have stated that the traditional financial reporting model is "too narrow to reflect what many modern corporations are trying to do." What businessmen are attempting to do is cope with expanding areas of accountability in their activities; recognize what is expected of them in terms of social performance; formulate policies and programs to attain social goals; and finally to communicate these efforts to outsiders, particularly to their critics. "Business executives want

such a system (of social accounting) because, as they come under increasing pressure to pursue social as well as financial goals, they are anxious to demonstrate in 'objective' terms that their enterprises do indeed benefit society. The current absence of agreed-upon standards makes it hard to put forth a convincing case to satisfy critics they complain."[35] Such an executive is D. S. Langsdorf, senior vice president and comptroller of the Bank of America who predicts that "within three to five years annual reports will be required to include data on a company's social outlays. Nobody plans to forswear profit as a gauge of business success. But many experts see the eventual measuring of social accomplishment as an inevitable adjunct, whatever method eventually is decided upon."[36]

It appeared that legal force for disclosing activities in certain social areas would be provided by the Securities and Exchange Commission Release of July 19, 1971, relating to "Disclosures Pertaining to Matters Involving the Environment and Civil Rights."[37] This release requires "disclosure, if material, when compliance with statutory requirements with respect to environmental quality, e.g., various air, water, and other anti-pollution laws, may necessitate significant capital outlays, may materially affect the earning power of the business, or cause material changes in registrant's business done or intended to be done."[38] It also calls for "disclosure, if material, when legal proceedings, arising under statutory requirements relating to Civil Rights would, for example, result in the cancellation of a government contract or termination of further business with the government."[39] Andrews notes, however, that "The SEC action disappointed corporate critics. They had hoped to use the disclosure provisions to force out a whole raft of secret corporate

data. They had asked the commission specifically to require companies to disclose how much they polluted the environment and to make public their confidential reports to the government on hiring and promoting minorities."[40] One can reasonably assume that these business critics will continue their efforts to have the SEC require businesses disclose this desired information if it is not revealed voluntarily in the meantime. Andrews continues by stating that "Meanwhile, the accounting profession, which sets the rules by which companies report their financial results, has so far taken no steps to require socially related data in routine corporate reports. Such a requirement might not be far off, however."[41] The question of who will provide information enabling one to evaluate the social performance of business entities will be the topic of the next section.

Social Accounting by Accountants?

It appears from previous discussions that formalized reporting models including not only the traditional economic indicators of performance, but also portraying evidence of social accomplishments, will be forthcoming. Accountants have customarily provided the financial reports of business entities although their efforts have been and continue to be criticized as previously noted. The great majority of this information is presented in dollar measures. The requirements of the expanded reporting model will certainly include some additional dollar quantitative measures. Indications are, however, that supplemental, noneconomic quantitative data will also be reported. The Committee on Environmental Effects of Organizational Behavior concluded that "In addition to traditional measurements, accountants may be required to

attest to various nonfinancial measurements. Examples would be attestation to physical measures of emission or to compliance with pollution control standards."[42] The question now to be considered is who is to develop the standards and procedures for the recognition, recording, summarization, and reporting of this information?

Beams and Fertig state that "The demand for information on the social responsibility of firms will be met by others if accounting does not rise to the challenge of supplying it."[43] They also note that "There is a tremendous demand for this type of information on social responsibility from widely diverse groups (investors, law-makers, politicians, economists)-- and it is not available. Organizations like the CEP (Council on Economic Priorities) are responding to the demand. Some organizations may try to make impartial, unbiased, complete and accurate reports to the best of their ability--whatever it may be. Other organizations may themselves be responding to a profit motivation (consultants?). These organizations are without standards, without discipline and lacking the professionalism of accountancy with its guardian, the AICPA."[44] (my insert) The expanded reporting model is the culmination of Prince's work. This is evident from his recommendation that "Another arrangement of the data on the income statement would be to have three sections: economic, psychological, and sociological. The data would be separated into these three areas according to its nature or characteristics."[45] Churchman's position is clearly designated in his statement that "if we (accountants) are to serve society by measuring social change, I think we'll have to do so in an entirely different mode from the traditional one of being the separate, disinterested, and objective observer."[46]

The above comments relate the opinions of individual accountants regarding the expansion of accounting's activities into the realm of developing indicators of social responsibility for business firms. A more convincing case for this position can be gleaned from recent professional activities in this area.

The American Accounting Association, composed predominantly of academicians, has traditionally been a leader in proposing advanced accounting concepts, procedures, and disclosures. A committee on Environmental Effects of Organization Behavior was appointed by the Association and charged with developing "measurement and reporting methods useful in communicating to internal and external users the effects of an organization's behavior on the physical environment. Attention should be given to measuring and reporting the environment effects of alternative modes of operations."[47] While the Committee's report, which appears in the 1973 Supplement to the Accounting Review, does not constitute the position of the Association, it does indicate that this segment of the accounting profession considers the development and communication of indicators of social performance of business entities an area of activity in which the profession should be involved.

The American Institute of Certified Public Accountants is composed predominantly of practicing CPA's. A study group of this organization completed a report entitled "Objectives of Financial Statements,"[48] in October, 1973. It was noted in the report that "Only society--through laws and regulation--can identify what is considers a cost or sacrifice. And only society can determine the extent to which it will absorb such costs or force enterprises either to modify their activities to eliminate social costs or else pay for them. In these ways, social costs become

private costs that affect enterprise earnings and earning power."[49] The study group developed a number of objectives of financial statements, one of which states that "An objective of financial statements is to report on those activities of the enterprise affecting society which can be determined and described or measured and which are important to the role of the enterprise in its social environment."[50] The Financial Accounting Standards Board is the successor to the Accounting Principles Board and is now the accounting authority on matters concerning accounting and reporting for business entities. The Board issues discussion memorandums to members of the profession which serve as a basis for public hearings before ruling on matters concerning proper accounting or reporting of the subject items. FASB Discussion Memorandum of June 6, 1974 was entitled "Conceptual Framework for Accounting and Reporting: Consideration of the Report of the Study Group on the Objectives of Financial Statements"[51] in which it adopted the above objective, as stated, with the request that interested parties respond to the question "Are financial statements likely to be the most effective means for presenting information about the 'activities of the enterprise affecting society'?"[52]

The above discussion would indicate that the accounting profession considers the development of indicators of social performance of business entities as a natural extension of the accounting function. Accountants have historically taken the lead in supplying increased information in business communication systems. Each additional data requirement has increased the accountant's responsibility in terms of adequate and fair disclosure and attestation to the amounts reported in financial statements. Providing this needed service to business offers new opportunities and challenges for accountants as well as new responsibilities.

An Attainable Level of Measurement

Accrual Accounting for Pollution Outlays?

Beams and Fertig make the following recommendation which states that "in the absence of adequate measurement methods, firms will generally account for pollution outlays as expenses . . . cash-basis accounting will make the income statements of delinquent firms appear more favorable than statements of firms which are voluntarily assuming responsibility for pollution control. Accounting needs to apply accrual accounting procedures to pollution costs in order to obtain comparability in published reports. The accounting reports should also provide additional disclosures that will give the reader some basis for assessing the responsibility that firms or industries should assume."[53] For the great majority of cases in the foreseeable future, society is going to require certain standards of performance in the area of pollution through regulation; and this will, of course, determine the level of responsibility that firms will assume. In addition, accrual accounting, by nature, requires the exercise of professional judgment in recording, apportioning to fiscal periods, and reporting economic events of business entities. Utilizing accrual accounting concepts to estimate costs and liabilities of firms that fail to expend funds to meet socially desirable goals appears to be an attempt to start at a level of measurement above that presently available. For those firms in industries that are not under the control of pollution standard laws, omission of relevant indicators will enable them to be compared with other firms in the industry that do include socially desirable goals in their decision processes.

Churchill's Four Levels of Measurement

Churchill discusses four levels of social measurement as inventory, input, process, and results.[54] The basic, or inventory, level is fairly obvious as this measurement procedure concerns what the firm is doing that has social relevance. "The second, or input, level involves determining the categories and extent of the efforts being expended in each of the identified, socially relevant activities." The third level of measurement--process--identifies and enumerates immediate outputs (tons of water filtered, tons of particulate residue captured in precipitators, etc.). The fourth level of measurement--results -- involves both an identification of what is being accomplished and an evaluation of the worth the accomplishment has for society. This is more than an enumeration of the immediate results and can involve second order effects, foregone alternatives, and displaced activities."

For this research project, the inventory level of measurement will be confined to what the firm is doing in the area of pollution control which is an assumed socially relevant activity. The input level of measurement will be limited to the direct expenditures related to attaining desired levels of pollution control. The magnitude of the expenditures will be the extent of the efforts being expended in this socially desirable activity. It is expected that the third level of measurement will be reached as physical quantities of residuals removed from productive wastes will be enumerated to indicate the attainment of desired standards. The portrayal of the efforts and physical quantities of residuals removed from productive activities over a period of time will identify what the firm is accomplishing in terms of reducing or minimizing its negative physical impact upon the environment. The worth of this

activity for society as a whole is inherent in the standards which have been imposed on the firm. For those firms that are not under the force of legally imposed standards, activities in this area must have been deemed socially desirable by the responsible officials of the entity; otherwise, why expend the firm's scarce resource in this area? It is envisioned that this is the highest concept of measurement that will be attained by the expanded reporting model to be developed in this research project. The second order effects of the fourth level of measurement of "foregone alternatives" and "displaced activities" will not be considered.

The measurement levels utilized in this research project may be from the lower stratum but they have the distinct advantage of being immediately determinable, for the most part, and serve the purpose of conveying entity efforts to attain noneconomic goals. Higher level measures must await considerable theoretical development and practical application. Prince explicitly supports this position when he states that "In terms of the accounting model, the operational answer will consist of the new motivational assumption (maximization of long-term income) and the old measurement and communication postulates. In other words, the operational answer is a very practical answer of how to get better information--'better' in the sense of communicating more of the real world--using the present method of doing things; that is, the present methods and procedures of measurement and communication. The operational answer can be immediately implemented."[55] (my emphasis) Another significant advantage of utilizing existing measurement and communication capabilities is that it will permit the additional social indicators to be attested to by independent auditors relatively quickly. The previous

comment by the Committee on Environmental Effects of Organizational Behavior explicitly called for verification of quantitative measurements by auditors. The Committee also recommends "that every firm be required to report and its auditors attest to a verbal statement which includes the following critical events: (a) Identification of environmental problems; (b) Abatement goals of the organization; (c) Progress of the organization; (d) Disclosure of material environmental effects on financial position, earnings, and business activities of the organization."[56]

Thus the urgent need is for an expanded accounting model which includes an additional section that narrates the pollution problems of the entity; displays efforts, in the form of expenditures, to meet these problems; and portrays quantitative data concerning the magnitude of the firm's effluents from the productive process on a comparative basis for several years. The development of this expanded accounting reporting model is the projected end product of this research project.

The Expanded Accounting Reporting Model Described

Discussions to this point in this chapter appear to indicate three things: (1) There is a need for a broader communication device portraying business entity efforts and accomplishments in both the area of economic and social activities. Hopefully this will enable business to respond more effectively to critics and the tide of legislative constraints. (2) This need is not presently being met by the existing accounting reporting model or any other formalized reporting device. (c) Expanding the traditional accounting reporting model to include indicators revealing efforts by business entities to recognize and

effectively respond to social responsibilities is practicable and will satisfy this communication need.

The end product of this research project will be the presentation of an expanded accounting reporting model which is offered as a vehicle for meeting the increased communication requirements of businesses attempting to operate in a more demanding cultural environment. The expanded model will be limited however, to the consideration of efforts and accomplishments of the firm in the area of pollution effects of its operations. The possibility exists for expanding the model into other areas of social activities of business organizations. This will be discussed more fully in the last chapter of this dissertation. The proposed expanded accounting model will include a supplemental Environmental Impact Report to be included with the traditional financial statements in the annual stockholders' reports. This supplemental Environmental Impact Report will contain a brief narrative section outlining the entity's pollution problems and efforts--past, present, and planned--to deal with them. Following the narrative section will be a 5-year schedule of social investments in pollution abatement facilities and the social costs of operating these facilities. Quantitative estimates of pollutants flowing from the productive processes will also be displayed for the same 5-year period. The last section of the supplemental report will contain a statement as to whether the entity is in conformity with pollution standards.

It is further proposed, and demonstrated in Exhibits 2 and 3 in Chapter 5, that the traditional statement of financial position shows, as a separate item, social investments in pollution abatement facilities and that the traditional income statement shows, as separate items, depreciation on

social investments and social operating costs.

The contribution of this dissertation will be the description of the methodology for recognizing, recording, summarizing, and reporting efforts (expenditures) and accomplishments (the social benefits of reduced pollution) of business entities in the socially desirable area of protecting the environment. The research project will also portray a proposed expanded accounting reporting model encompassing a formalized social indicator reporting device. Such an expanded, formally structured communication system is not presently available to meet the needs of business.

Summary

The first chapter of this dissertation has been directed to developing materials which indicate: (1) Operations of business entities, particularly manufacturing concerns, have produced substantial negative impacts upon the physical environment; (2) The cultural milieu in which business must operate has reacted to this phenomenon by imposing additional constraints upon business activities; (3) Business entities need a communication device indicating both efforts and accomplishments in economic as well as social areas of firm activities; (4) The present financial accounting reporting model is too narrow to reflect business's attempts to recognize, and effectively respond to, social responsibilities desired or imposed by society; and (5) The expanded accounting reporting model proposed and illustrated in this research project will meet the needs of businesses attempting to operate in a more demanding cultural environment.

Until fairly recently, business entities were permitted to produce

their output of goods or services for the market with little or no consideration given to the "external diseconomies" or negative impacts of their operations upon the physical environment. The traditional "free" factors of production, air and water, were used as repositories of industrial wastes. As industrial societies expanded, these negative effects, called pollution, reached such magnitudes as to destroy resources and property and inflict injury and even death upon thousands of people. Some scientists even contend that the "earth's natural balance" has already been thrown off with potential disastrous results for mankind.

Society has reacted to this state of affairs by imposing additional legislative constraints upon business entities even to the extent of forcing some firms out of existence with the resultant loss of the positive aspects of their economic activities. Businessmen's attempts to communicate their recognition of, and efforts to respond effectively to, social responsibilities, have lacked a formalized structure. The result has been ineffective responses to critics and minimal success in stemming the tide of legislative constraints.

The end product of this research product will be a proposed expanded accounting reporting model which will include a supplemental Environmental Impact Report with the traditional financial accounting statements. This Report will narrate the entity's pollution problems and expenditures (efforts) made and planned, to deal with these problems. A 5-year schedule of social investments in pollution abatement facilities and social costs of operating these facilities will be presented. Also, a 5-year schedule of estimated quantities of pollutants produced by the entity will be included. It is expected that as expenditures for abatement facilities increase, the quantities of pollutants will decrease (accomplishments).

The Report will contain a statement as to whether the firm is in compliance with existing pollution standards. In addition, the traditional statement of financial position will be expanded to show social investments in pollution abatement facilities and the traditional income statement will be expanded to show social depreciation and social operating costs as separate items. This proposed expanded accounting reporting model represents a formally structured communication device portraying efforts and accomplishments in both the economic and social areas of activities of the entity. It is believed that this reporting model will meet the needs of businesses attempting to function in a changing cultural environment.

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CHAPTER II

INDUSTRY SELECTION AND RESEARCH METHODOLOGY

Introduction

The first chapter of this research project was devoted to the presentation of significant background information concerning the negative physical impact of economic activities upon the environment and the cultural reaction to this state of affairs by increased legislative constraints upon business.

The present chapter has two major objectives. The first is the selection of the industry to be studied and the presentation of the criteria utilized in the selection process. The second objective will be to outline the research methodology to be used in studying the selected industry. The final result of the project is the development of the illustrative expanded reporting model. The significance of the research project, as previously noted, is the presentation of the method for recognizing, recording, summarizing, and reporting expenditures for social purposes as well as other pertinent data indicating the recognition and attainment of social goals.

Research Needs

Case Studies of Polluting Industries Needed

The Committee on Environmental Effects of Organizational Behavior of the American Accounting Association suggested as an area for further

research the question of identifying expenditures for pollution control. The committee states that "Perhaps case studies could be used to produce criteria useful in identifying pollution control costs and expenses."[1] Kneese makes the comment that "Perhaps the most fruitful approach for research would be intensive study of each of the major water-using and polluting industries in terms of its overall, interrelated effects on, and response to, the water resources environment. These relationships can be classified into three elements. First, the withdrawal of water from the water resource. Second, water depletion by evaporation or incorporation in the product. Finally, the quality characteristics of the water returned to the stream. Each element is capable of variation within technically defined limits, and variation of one element tends to be reflected in the others."[2] Kneese continues by noting that "Among the industries that merit specific investigations are: food and kindred products, pulp and paper, petroleum and products, iron and steel, textiles, rubber and products, and chemicals group . . . These investigations are of the first order of importance because industrial wastes are a very large and potentially variable part of the total wastes delivered to receiving waters."[3] While the above comments do not present any quantitative criteria for evaluation, they do tend to support the area of research, the case study method, as well as the industry selected.

Choosing an Industry

Choice: The Pulp and Paper Industry

The industry selected for the research study is the pulp and paper industry. In terms of various elements of size that might be considered in the selection decision, it is relatively easy to develop comparative tables listing industries and their total sales, assets, etc. As we shall

see, however, no industry maintains the same comparative ranking as we go from one criteria to the next. Furthermore, as we examine other equally important criteria, the ability to neatly rank industries becomes more difficult or impossible. This is particularly true in the case of attempting to determine the total environmental impact of industrial activities. In view of this state of affairs, it is only considered necessary to show that the industry selected is one of the major industries in the country in terms of various economic indicators and is considered to be one of the major polluting industries.

Absolute Size vs. Rankings

It seems logical that the industry selected for a study such as this should not be a small one with relatively minor localized environmental effects. A more appropriate industry would be one which is at least national in scope of operations and physical impacts.

There are many different elements of size of entities and industries and no firm or industry will rank first in all aspects being judged. For example, for manufacturing industrial firms, in 1973[4] General Motors ranked first in sales with $35.8 billion but ranked second in both assets ($20.3 billion) and net income ($2.40 billion) behind Exxon, $25.1 billion and $2.44 billion, respectively. In terms of assets, both industrial firms were overshadowed in 1973[5] by American Telephone and Telegraph Company ($67.1 billion), BankAmerica Corp. ($49.4 billion) and Prudential Insurance Company ($35 billion). None of the nonindustrial firms come close to matching General Motors' volume of sales. The American Telephone and Telegraph Company operating revenues of $23.5 billion for 1973 places it slightly behind Exxon's $25.7 billion. Changing the element of comparison to net income produces a still different ranking.

American Telephone and Telegraph's net income for 1973 of $3 billion far exceeds Exxon's $2.44 billion and General Motors' $2.4 billion. The net incomes of all three of these entities dwarf, by comparison, the net income of BankAmerica Corp. of $221 million and Prudential Insurance Company's $57.1 million net gain from operations. Thus as we change the basis for comparison, the rankings of firms and industries will change.

Current Values and a Different Ranking?

If we could change the criteria of evaluation from book value of assets, as presented above, to the current value of assets, then another company might possibly outrank American Telephone and Telegraph Company. For example, it is revealed that "International Paper, the largest company in the (pulp and paper) industry, ranks second only to the Federal Government in total acreage across the country . . . Paper companies control about 52 percent of the land area of the state of Maine . . . Boise Cascade (in a joint corporate venture) is the largest land owner in the state of Louisiana . . . The estimated total land holdings of all pulp and paper companies amounts to fifty million acres, an area equal to all of New England and New Jersey."[6] In view of the fact that the pulp and paper industry is older than many others (automobiles, communications, etc.) it seems reasonable to assume that a significant portion of these land holdings were acquired at costs substantially below current values. This situation reflects one of the classical criticisms of accounting reports, book values of assets at historical costs which may vary considerably from current values.

An even more significant point concerning the substantial land holdings of pulp and paper companies must be made. Historically, and to a

large extent even today, land holdings are equated with power, political as well as economic. This political power manifests itself most clearly in localized areas where a pulp and paper mill may be the dominant economic entity. One might also wonder about the political power exerted at the state level in view of the above comments. With such concentrations of wealth, it is easy to understand how individuals and even whole communities are unable to assert influence upon corporations to refrain from or lessen their pollution levels.

Some Comparative Quantitative Data

Attention will now be directed to the presentation of data showing the absolute magnitudes of various indicators of the size of the pulp and paper industry as well as rankings with other industries or percentages of industrial totals in terms of these indicators. In addition, the data will generally be presented at two different points in time. This will support the proposition that not only is the pulp and paper industry a major industry in terms of most size criteria presented, but it is also a growing rather than a stagnant or declining industry.

The first indicator to be presented will be the net value added to production by the paper and allied products industry. The source for the absolute amounts, the components of computations and rankings is the schedule of national income by industrial origin contained in the 1974 Statistical Abstract of the United States.[7] In 1960, the national income from the paper and allied products industry amounted to $4.7 billion. By 1972, this figure had risen to $9.3 billion. In 1960, the paper industry accounted for 3.4 percent of the total national income from all manufacturing. In 1972, this had risen to 3.7 percent. In both 1960 and 1972,

the paper industry ranked fifth in total value added among 11 nondurable goods industries listed and eleventh among the 21 manufacturing categories listed (nondurable and durable goods).

Another indicator of size is sales which is, of course, a gross concept encompassing an accumulation of values added by other firms or industries. The source for this data is the 1973 Business Statistics: The Biennial Supplement to the Survey of Current Business[8] published by the Department of Commerce. In 1960, the paper and allied products industry had sales of $14.6 billion. By 1972, sales had grown to $28.3 billion, an increase of 94 percent. This represents 8.1 percent of total nondurable goods industries sales in 1960 and 8.2 percent in 1972. In 1960, the paper industry accounted for 4 percent of all manufacturing sales but by 1972 this percentage had declined to 3.8 percent. In terms of rankings, the paper industry stood fourth among nondurable goods industries in sales in 1960 and 1972. Among all manufacturing industries, paper ranked ninth in sales in 1960 and 1972.

The labor/capital dichotomy that exists for all entities results in a changing conglomeration of factors of production as temporary imbalances in returns to the factors may occur. This situation, plus the general scarcity of labor, has necessitated heavy capital investments, particularly in many manufacturing industries. In 1967, the book value of depreciable assets[9] for all manufacturing industries aggregated $218 billion. By 1971, this had grown to $277 billion. The paper industry accounted for $16 billion of the total in 1967 and $20 billion of the total in 1971 or, 8.7 percent and 7.2 percent, respectively. In 1967, the paper industry was tied for fourth rank among all manufacturing industries (durable and nondurable goods) in this category but was ranked fifth in 1971.

In analyzing expenditures for new plant and equipment[10] it was noted that all manufacturing industries spent $10.1 billion in 1960, of which $655 million or 6.5 percent was accounted for by the paper industry. In 1972, all manufacturing industries spent $22.9 billion on new facilities. The paper industry spent $1.4 billion or 6.1 percent of the total. A more directly related indicator of a significant industry is from the standpoint of capital expenditures for pollution control facilities. Actual expenditures for all manufacturing industries for pollution control facilities in 1969, according to a study by Lund,[11] amounted to $394 million, of which $44.2 million or 11.2 percent was spent by the paper industry. Investment in capital facilities for pollution abatemen inherently increase costs for their operation and upkeep. As Barker notes, "It is estimated that every dollar of capital investment in pollution control adds an additional 10¢ in annual operating and maintenance costs."[12]

Numerous additional industry statistics could be presented. Number of employees, industrial production indexes, investment per employee, sales dollars per employee, sales dollars per dollar of investment, return on assets and return on stockholder's equity are but a few. However, the assertion that the paper industry is one of the major industries in the United States has been adequately documented.

Physical Impacts

Considering the fact that it is the substantial negative impact upon the environment produced by economic activities which brought about the circumstances underlying the need for this research project, the relative position of the industry in terms of negative environmental impact should carry more weight in the selection process than economic indicators. As

the following presentation shows, the pulp and paper industry is one of the leading sources of industrial pollution.

Economic Resources vs. Physical Impact

Even though a firm or an industry may be enormous in terms of the economic resources it controls, it does not necessarily follow that the environmental impact of its activities will begin to approach that of firms or industries substantially smaller. A previous discussion indicated the significantly larger quantities of assets controlled by the American Telephone and Telegraph Company, BankAmerica Corp., and Prudential Insurance Company of America in comparison to those held by General Motors Corp. or Exxon Corp. It is reasonable to assume that the direct activities of the communications, banking, and insurance industries produce a far less negative environmental impact than either the petroleum or automobile manufacturing industries.

Some Major Sources of Pollution

Ethridge states that "The major sources of pollution from industry are food processing, pulp and paper, chemicals, and petroleum products."[13] This appears to be substantiated by Kneese who notes that "Domestic sewage is the most widespread source of degradable organic wastes, but industry contributes about an equal amount. The food and pulp and paper industries are the greatest generators of such wastes, and in some instances individual plants emit massive loads."[14] Goldman and Shoop state that "Oxygen exhaustion is an especially serious problem for streams which receive wastes from paper pulp mills. These plants may discharge unusually large quantities of effluent, depleting all available dissolved oxygen. Since paper pulp mills are normally located near woodlands, they may be

particularly destructive of natural wildlife."[15]

A measure of pollution that has been developed is biochemical oxygen demand (BOD) which indicates the oxygen demand placed upon receiving waters by discharged organic wastes. Excessive BOD of effluents over a period of time can alter the fish-plant life cycle of the body of water. The result is lower forms of life (i.e., algae, etc.) and the elimination of desirable species of fish and plants that cannot survive in the oxygen starved waters. The magnitude of this phenomenon was previously noted in the discussion of the pollution of such a large body of water as Lake Erie. Significant contributors to the destruction of this resource was the discharge of raw or superficially treated sewage from the city of Detroit in addition to industrial effluents, including a number of pulp and paper mills that line the shore of the lake.

Lake Baikal in Russia is the largest fresh water lake in the world, containing 10 percent of the earth's fresh water supply. Volkov[16] discusses the threatened pollution of the lake from the Baikal and Solenga pulp and paper mills because of inadequate waste treatment facilities. An even greater threat exists, however, from the stripping of the forest cover in this mountainous region resulting in washing away of surface sands into Lake Baikal and its tributaries. Volkov describes this phenomenon by stating that "Lake Baikal's tributaries will carry seven times as much sediment into the lake as now. Incidentally, as a result of timber cutting in the southeastern United States and the subsequent soil erosion, thirteen bodies of water were silted up in less than a decade and a half."[17]

Other Indications of Pulp and Paper Pollution

More specific indications of the relative position of the pulp and paper industry in terms of negative environmental impact is divulged by Allan, who notes that "Statistics from as recently as 1964 show that the industry (pulp and paper) was responsible for 23.5 percent of the industrial effluent discharge in the Northeast, 26.4 percent in the Southeast, and 16.7 percent in the Pacific Northwest . . . in 1969, it is estimated that the industry discharged 15 percent of the total industrial effluent of the United States."[18] (my emphasis) It is not difficult to conceive of this fact when we consider that in 1969, "the industry 'borrowed' over two trillion gallons of water . . ."[19] In 1969[20] the pulp and paper industry consumed 65.9 million cords of wood, each containing 128 cubic feet. By 1972 consumption of woodpulp had increased to 69.2 million cords.

The statement above that the industry "borrowed" over two trillion gallons of water is significant. The implication is that the water is not consumed but merely used and discharged into some receiving basin. "Although the industry constantly reiterates that most of its water is not 'consumed' but only 'used' and returned to the waterways, a great amount and variety of waste matter is discharged in these trillions of gallons. There are heavy solids like fibers, bark, uncooked wood chips, and dirt; there are dissolved solids like carbohydrates and soluble wood matter; and there are the cooking and bleaching chemicals. Although they are not pathegenic, these pulping pollutants have disastrous effects on our waters."[21]

A study entitled "Water Use in Manufacturing,"[22] conducted by the Bureau of the Census, provides the means for ascertaining the pulp and

paper industry's relative position in terms of water usage and consumption. In 1968, the primary metal industries were the largest users and consumers of water. Their total water intake amounted to 5 trillion gallons while total water discharged amounted to 4.7 trillion gallons, resulting in a consumption of 307 billion gallons. Of the total water returned to receiving basins, only 1.4 trillion gallons or 30 percent was treated prior to discharge. The chemicals and allied products industry was the second largest user and consumer of water in 1968. Total intake was 4.5 trillion gallons, of which 4.2 trillion gallons were discharged, producing a consumption of 301 billion gallons. Of the 4.2 trillion gallons discharged, only 674 billion gallons or 16 percent were treated prior to release. Of all manufacturing industries, the pulp and paper industry ranked third in water use and consumption in 1968. Total water intake amounted to 2.25 trillion gallons, while 2.08 trillion gallons were discharged, resulting in consumption of 170 billion gallons. Of the 2.08 trillion gallons released, 915 billion gallons or 44 percent were treated prior to release. A significantly better showing than either the primary metals or chemicals and allied products industries.

Relative Position as Air Polluter

A study comparable to the Water Use in Manufacturing conducted by the Census Bureau is not available to ascertain the pulp and paper industry's relative position as an air polluter. It is possible to develop some feel for this standing from another source, however.

Considerable attention has been directed to the automobile as a major source of air pollution. The smog problem of Los Angeles is primarily traceable to this cause. Unfortunately, however, the adverse

publicity given to industrial air pollution (Pittsburg, the "smoky city") far exceeds its impact in this area. This is substantiated by Ross, who states that "Certainly it is true, and it can be proven statistically, that wastes from industry today contribute only about 20 percent to our total air pollution. We know that the internal combustion engine used in automobiles, buses, trucks, airplanes, and other modes of transportation contribute about 60 percent of all air pollution in the world today. Another 10 percent or more is caused by the generation of electricity for the ultimate comfort of people. Nevertheless, the average layman is ignorant of these statistics and he generally continues to assume that industry is the culprit, and since industry has caused the pollution, it must pay the bill."[23]

Dworsky states that "Substances which contribute to the pollution of air can be divided into two broad classes:

> Particulate matter consisting of solid and liquid particles varying widely in size from relatively large particles (one hundredth of a centimeter in diameter or larger) to suspended matter (particles less than two one-thousandths of a centimeter in diameter). Still smaller particulate matter are the aerosols (from one ten-thousandth to one-millionth of a centimeter in diameter);
>
> Gases and vapors including the permanent gases and those substances that have boiling points below about 200°C."[24]

The study edited by Ross,[25] previously cited, lists the annual quantities, in billions of pounds, of air pollutants by major industrial source. The pulp and paper industry is ranked fourth with 6.6 billion pounds behind petroleum refining (8.4 billion pounds), smelters (8.3 billion pounds), and iron foundries (7.4 billion pounds). The study also presents a table showing various types of polutants by source but not in such a manner that all of industry's share can be determined. However,

the total of all air pollutants is shown to be 172.8 million tons per year. Assuming that these data are from the same or comparable years (none is given for either listing), a few simple computations, using the percentages and figures given, permit the determination that the pulp and paper industry is accountable for 1.9 percent of all air pollution and 9.6 percent of all industrial air pollution. It seems evident, therefore, that the pulp and paper industry is a major source of air pollution resulting from industrial activity.

Other Types of Air Pollution

Our discussions to this point have been limited to the physical impact upon the air as described above in terms of particulates and gases and vapors. One area of environmental impact that is peculiar to the pulp and paper industry and not present in many other industries is the obnoxious odor produced by kraft paper mills. "The most annoying pollutants in terms of human comfort are hydrogen sulfide and the methyl mercaptans produced by chemical reactions in the kraft process. These gases are characterized by an 'ugly, pervading, penetrating, sickening stench,' which can be spread for thirty miles in a strong wind. According to a study on noxious odors . . . this kraft mill odor is the third most serious, affects the second largest area per source, and is the longest lasting of all our modern odors . . . In addition to its noxious qualities, hydrogen sulfide is highly toxic in large quantities."[26] In a report to the Washington (state) Air Pollution Control Board, it was noted that "odorous gases from a pulp mill can be detected up to fifty miles from the plant site."[27] The difficulty in eliminating this particular aspect of the kraft air pollution problem can be seen when it is

observed that "it (kraft mill odor) has been successfully reduced by 97 to 99 percent, to a level of one part per million in a mill in Sweden. 'From a strictly chemical viewpoint, the odorous compounds are essentially eliminated.' However, since the human nose can detect the smell at one part per billion, the problem is not yet solved."[28]

Another undesirable air pollution impact related to the pulp and paper industry not found in many other industries is the dense fog that settles near some mills. The most serious incident attributed to this particular problem is described as follows. "On November 28th and 30th, 1970, outside of Canton, North Carolina, massive, multi-car collisions (involving at least thirty-four vehicles) caused by the smog from the U.S. Plywood-Champion Paper mill, led to the injury of at least twenty-five people . . . The smog is so continuously dense near this mill that highway signs read 'Caution: Dense Fog Likely Next Four Miles.'"[29] Consequently, in the pulp and paper industry, not only do we have a significant source of air pollution described in traditional terms of tons of particulates and gases emitted from the production process but also the very undesirable odor and visibility problems as well.

Solid Wastes Pollution

A fundamental law of physics states that matter can neither be created nor destroyed. Through the operation of various physical or chemical processes, matter may be transformed from one state to another. The applicability of this law of physics to the pollution problem is that the reduction of one type of pollution may result in another, possibly more unacceptable type. A classic example is the fate of several tire reclaiming plants, designed to rid the land of unsightly piles of

discarded tires, which were forced to close because they couldn't meet air pollution standards.[30] Kneese et al., discusses the "tradeoffs among discharges to different environmental media . . ."[31]

The relevance of these comments to the pulp and paper industry can be seen from the solid waste pollution problem that emerges from the removal of tons of particulates from the smokestacks and the sludges that are produced by removing pollutants from liquid effluents. Two processes are utilized to remove wastes from liquid effluents resulting from the pulp and paper productive processes. They are primary treatment, a physical process which permits solids to sink to the bottom of the reservoir and the other method, secondary treatment, is a biological process designed to speed up the natural oxidation processes that occur in bodies of water. These systems remove significant quantities of pollutants in discharged waters of the pulp and paper plant, thereby substantially reducing the BOD (biochemical oxygen demand) effect upon the receiving waters. The end result of both of these processes is a sludge which must be eliminated. "The handling, dewatering, and disposal of primary and secondary sludges are important factors in the design and operation of water treatment facilities in the pulp and paper industry . . . Ultimate disposal of waste sludges is a 'solid waste' problem. In the past, these materials have generally been disposed of by landfilling and lagooning together with other mill wastes products, such as bark, ash, grit, and debris. However, with increasing land costs, decreasing land availability and more stringent regulations concerning solid waste disposal, recent solid waste systems have included incineration of primary and secondary sludges."[32]

In terms of its relative undesirable environmental impact, solid

wastes disposal is generally confined to the local area adjacent to the productive facility. This may be contrasted to the negative impact of polluted air and water, the effect of which may be extended for many miles from the plant, as we have seen. This localized characteristic of solid waste that results from the numerous productive processes may account for the lack of available studies showing the quantities of solid wastes produced by the major industries. Another important factor may be the ability of some industries to recycle significant quantities of solid waste materials. An example would be transportation equipment manufacturers which produce large quantities of scrap metal which may be remelted and utilized rather than posing a major disposal problem.

In view of the lack of studies indicating the quantities of solid wastes produced by various industries, it seems reasonable to assume the pulp and paper industry would rank as a substantial contributor to this environmental problem. The lack of a more rigorous foundation upon which to base this assertaion does not constitute a significant weakness in the criteria used in the selection process. This is because the environmental impact of solid waste is limited geographically in contrast to the effects of air and water pollution. More importantly, it has been previously stated and is here reasserted that no industry will rank high comparatively in all criteria utilized in the selection process. The selection of the pulp and paper industry on the basis that it is one of the major polluters of the environment has been adequately demonstrated.

Nearness of Industry

The vast numbers of people living in the heavily industrialized sections of America have experienced the diseconomies of industrial

activities. Many have felt the discomfort of smog. Many have seen the lakes and rivers that once provided recreational facilities for swimming, fishing, and boating diminish in attractiveness for these purposes because of pollution. In the more rural areas, many have witnessed the ravaging of the land by strip mining. Others have seen waterways spoiled by runoffs from mines or careless use of powerful chemical insecticides. Only a relatively small portion of the people continue to enjoy clean air and unspoiled waterways and countrysides free of the scars of our heavily industrialized society.

A Personal Encounter with Pollution

From my own personal experience I recall traveling over a small, dark water creek just north of Palatka, Florida many times as a boy. It was always one of the more scenic parts of the trip from my home town of Crescent City to Jacksonville. I remember visualizing a boat trip along its picturesque banks fishing for black bass or speckled perch. After the construction of a pulp and paper mill north of Palatka, crossing over this creek became a very unpleasant experience. The top of the water came to be covered with a green slimy-looking scum, and the odor was sickening. Periodic exposure to the stench of pulp and paper mills has been experienced by nearly everyone in northeast Florida. Within a 50-mile radius of Jacksonville, there are 5 large pulp and paper mills. This personal experience enabling me to relate directly to the negative impact of the pulp and paper industry weighed heavily in the selection process. Books, articles, pictures, movie or television presentation of pollution problems in other sections of the country bring forth a feeling of concern that something should be done to remedy the situation. However,

due to the distances involved and the inability to personally experience the pollution impacts, it becomes very difficult to realistically relate to the problems presented.

Pulp and Paper Industry in the Southeast

By expanding the area of concern to cover the Southeastern region of the United States, we find the pulp and paper industry to be one of the most dominant in the area. Basically, three chemical processes and one mechanical process are utilized to produce the pulp from wood which is further processed to provide paper of various grades. Of the three chemical processes accounting for 94 percent of all 1968 production[33] 75 percent was provided by the kraft (sulfate) process, 9 percent by the sulfite process, and 10 percent by the neutral sulfite semichemical (NSSC) process. The remaining 6 percent of production was by the groundwood mechanical process.

An analysis of the 1968 production and projections for 1975 and 1980 by regions[34] provides some interesting information. The dominance of the kraft process among the chemical processes is evident when it is shown that in 1968 this method accounted for 69,428 tons per day (TPD) of productive capacity out of a total of 86,571 TPD of all chemical pulp processes. This represents approximately 80 percent of the total. By the end of 1975 it is projected that the kraft process will account for 107,142 TPD of productive capacity out of a total of 126,284 TPD or 85 percent. The 1980 projections are 134,000 TPD out of a total of 155,428 TPD or approximately 86 percent. The Southeast section encompassed in the study is substantially smaller than traditional concepts of this region because it omits Kentucky (which has no pulp and paper mills), the western one-third of Tennessee, and all of Louisiana and Mississippi.

These geographical areas plus Arkansas, the eastern sections of Oklahoma and Texas, make up what the study calls the Southcentral region. Including the Southeast and Southcentral regions together to conform more to traditional ideas of the area indicates the dominance of the pulp and paper industry in this section of the United States. The productive capacity in this area was 52,099 TPD in 1968 with projections of 80,399 TPD in 1975 and 100,554 TPD in 1980. These figures represent 75 percent of the total kraft productive capacity in the United States for the respective years. It has been noted above that the kraft process is by far the dominant method utilized in the pulp and paper industry in 1968 and is projected to become even more predominant through 1980.

The above comments indicate that the pulp and paper industry is substantially situated in the Southeastern region of the United States and, accordingly, is most important to the region both from a positive economic benefit standpoint as well as from a negative physical impact standpoint. It is not herein implied that other substantial industrial activities are not carried out in the region. Petroleum and chemical industrial complexes, both major polluting industries, are located along the southern Gulf coast, particularly in Louisiana and Texas. The area around Birmingham, Alabama is well known for the pollution effects of its steel-making industries. Also, mining and strip mining operations in the Appalachians have significant environmental impact. It is contended, however, that none of these economic activities approach the pulp and paper industries in terms of covering the entire geographical area or in terms of magnitudes of almost any criteria selected, particularly negative environmental effects.

The remainder of this chapter will be devoted to describing the

research methodology to be utilized in studying the industry selected in order to achieve the research project objective of presentation of an expanded reporting model.

Research Methodology

A Case Study Approach

Previous comments have indicated that case studies should be made of the various polluting industries. One method of applying the case study approach is to obtain actual data from an operating entity. This procedure will be followed in this research project.

As previously indicated, there are five pulp and paper plants located within a fifty-mile radius of Jacksonville. This fact makes the study of one of these facilities feasible in terms of personal resource requirements for travel, etc.

Permission has been obtained to secure operating and financial data to the extent that it is available. Preliminary studies indicate that data sources are adequate for the needs of this research project. The only constraints that have been placed upon the study are that the company selected not be specifically identified and that actual financial results not be divulged. These restrictions are considered to be reasonable and quite common for this type of research. They offer no obstacle to the attainment of the research objective. Some characteristics of the plant and an outline of the research procedures follow.

Outline of Research Procedures

Most of the pulp and paper plants in Northeast Florida are approximately 20 years old. This places them in the classification of "today's

technology"[35] according to the Federal Water Quality Administration. These plants may be relatively efficient in terms of raw materials/ output ratios but they generally do not reflect the latest technology available to minimize their negative environmental impact.

The first research procedure will be directed at describing the productive facility as it existed as of December 31, 1969. Flow diagrams will be developed modeling the kraft pulping and paper and linerboard making operations. Also to be presented will be diagrams of the chemical recovery processes, as well as the by-products produced and the electric power generating facilities of the plant. A brief, nontechnical description will be given of all of the plant's operations. This step is considered necessary to convey a general understanding of the manufacturing processes involved. This will enable the reader to relate the pollution points to be identified to the area of the plant's operations. This effort will constitute Chapter 3 of the dissertation.

The next research procedure will encompass Chapter 4 where pollution sources, quantitative estimates, and abatement facilities will be enumerated. Tables displaying sources and estimates of pollutants from the productive configuration in existence at December 31, 1969 will be developed. Another table will list the pollution abatement facilities in use at the plant at that point in time. A condensed flow chart of the mill will visually display the location of both the sources of pollutants and existing abatement facilities. Brief descriptions of these facilities will also be given. The next section of this chapter will be devoted to listing and briefly describing the in-plant changes made and abatement facilities acquired during the five years ended December 31, 1974. Revised schedules of quantitative estimates of pollutants will be developed

which should reflect significantly decreased negative environmental impacts in light of the changes or acquisitions made. Revised flow diagrams will be presented emphasizing the changes made and the facilities acquired. Costs shown in the individual tables will be divided into capital and social expenditure classifications depending upon economic benefits accruing from changes made or facilities acquired.

The final research operation, to be presented in Chapter 5, will accumulate statistical data for inclusion in the Environmental Impact Report and for separation in the expanded financial statements. The monetary aspects of the data will encompass the annual operating expenses that are incurred for pollution abatement activities of the plant. These are to be shown in the expenditure section of the Environmental Impact Report as well as being shown as social expenses in the expanded income statement. Also shown in this section of the Environmental Impact Report will be the social capital expenditures developed in Chapter 4. These expenditures will be shown by years over the five-year period covered by the Report. Also gathered for this chapter will be the physical quantities such as paper and linerboard produced for the period covered. This data is to be used to develop the physical environmental impact of the plant's operations over the five-year period. It is expected that monitoring devices measuring the quantities of pollutants expelled or the efficiency of abatement facilities utilized will be almost nonexistent over most of the period except for possibly some of the latest acquisitions. In view of this, the estimated negative environmental impact from the productive processes will be computed utilizing quantities of pollutants developed in Chapter 4.

Attaining the Research Objective

The end product of the research procedures outlined above will be the Environmental Impact Report to be included in the traditional report to outsiders. The simplifying assumption will be made that the plant studied is a separate operating, reporting entity instead of one plant in a multi-plant corporation. Another simplifying assumption will be the presentation of fictitious financial data in the statement of financial position and the income statement, the only two financial statements to be developed. Nothing is to be gained from the exercise of developing a full set of financial statements complete with notes, auditor's opinion, etc. The only effect upon traditional financial statements of the expanded reporting model is the presentation of expenditures for abatement facility acquisition and operation as social asset and expense classifications. The major aspect of the expanded reporting model will be the Environmental Impact Report to be included as supplemental information in reports to outsiders. The report will narrate the firm's pollution problems and efforts to bring these problems under control. The monetary section of the Report, as previously indicated, will portray expenditures for abatement facility acquisition and operation over the five-year period. The physical impact section of the Report will present operating statistics and estimated pollution quantities resulting from the plant's operations. It is expected that as expenditures increase, the negative physical impact of the plant's operation will diminish. Finally, the Report will indicate whether the plant is in compliance with governmental pollution standards. This report will portray the firm's recognition of, and efforts to constructively respond to, its social responsibilities in the area of physical impacts upon the environment. While the expanded

reporting model is the culmination of the research project, the significant contribution is the presentation of a method for recognizing, recording, summarizing, and reporting expenditures for social purposes and environmental impact data.

Summary

Chapter 2 has been directed towards two major aspects of the research project, the selection of the industry to be studied and outling the research methodology to be utilized. The industry selected is the pulp and paper industry. The criteria utilized in the selection process was then enumerated.

A brief comment was interjected indicating support for the case study approach to research of industries with extensive pollution problems. It was then demonstrated that from the standpoint of size, as we go from one criteria to another, the rankings of firms or industries change. It was concluded, therefore, that it was sufficient to establish that the industry selected is one of the major industrial classifications in terms of economic and environmental impact indicators.

The economic indicators presented in absolute amounts and with respect to rankings among all manufacturing industrial classifications were net value added to production, sales, book value of depreciable assets, expenditures for new plant and equipment, and expenditures for pollution abatement facilities. Generally, absolute amounts and rankings at two points in time were presented to substantiate the assertion that the pulp and paper industry experienced significant growth over the period shown. The presentation of economic indicators supported the allegation that the industry selected is a major force in the manufacturing section of the American economy.

When attention was directed toward environmental impacts of industry activity as criteria supporting the selection, it was shown that the pulp and paper industry ranked higher in this area than in any economic indicators. With respect to water pollution, it ranked third among all industrial classifications. It was illustrated that it is one of the major industrial polluters of the air.

Another important selection criterion was the nearness of the industry reflecting personal encounters with its negative environmental impacts. It was also shown that this industry is not only important to this area of the state but,also is probably the major industrial activity in the Southeastern section of the United States.

The last part of the chapter was directed toward outlining the research methodology to be used in the project. A case study of an actual operating kraft pulp and paper plant located in Northeast Florida is to be made. The only restrictions placed upon the researcher are not to identify the company and not to reveal any actual financial operating results. Both constraints are considered reasonable and will not interfer with the attainment of the research objective.

The first research procedure will be to outline, by flow chart, and describe, in nontechnical terms, the productive facility as it existed at December 31, 1969. This will be done in Chapter 3 and will include the pulp and paper and linerboard-making operations, the chemical recovery processes, the by-products manufactured and the electric power generating plant.

Chapter 4 will present schedules of the pollution abatement facilities on hand at December 31, 1969 and abatement facilities and in-plant changes made during the five-year period ended December 31, 1974. Brief

descriptions will be given of the facilities acquired and the changes made and revised flow diagrams will be developed indicating their location in the manufacturing facility.

The major objective of Chapter 5 will be to illustrate the proposed expanded accounting reporting model which includes the supplemental Environmental Impact Report. Statistical data will be accumulated to be included in the expanded reporting model.

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CHAPTER III

MODEL OF A KRAFT PULP AND PAPER PLANT

Introduction

Chapter two of this dissertation presented the industry selected for study, the criteria underlying this selection, and an outline of the case study procedures to be completed in order to attain the overall objectives of the research project.

The present chapter has two functions to accomplish. First, an outline of the manufacturing processes for making kraft pulp, paper, and linerboard will be presented in flow chart form as it existed at the plant at December 31, 1969. This point in time was chosen for two reasons. First, it is expected that, at this time, little if any of the more modern pollution abatement facilities would be in operation. Second, the plant is approximately fifteen years old at this point, which places its productive processes in the classification of "today's technology," as previously noted. The second function of this chapter is to narrate a nontechnical description of these manufacturing systems, enabling the reader to obtain a general understanding of the kraft pulp, paper, and linerboard productive processes. This is necessary in order to more easily relate subsequent discussions concerning pollution points, estimates, abatement facilities acquired, and in-plant changes made to an area of the productive process.

Models of kraft pulp and paper plants contained in the literature

as well as those available from the plant operating personnel, tend to be quite complex. The reason for this is that they encompass the raw material storage and preparation, pulping, papermaking, and chemical recovery systems all in one diagram. In addition, bleaching and converting operations, neither of which are used at the plant studied, may also be included. Furthermore, electric generating systems and by-product facilities may also be shown.

In order for the kraft manufacturing process to be economically feasible, it is imperative that a great majority of the chemicals used in the process be recaptured for reuse. The chemical recovery process, at least diagramatically, is the most complex configuration in the whole plant. In view of this state of affairs, the presentation will be divided into 5 sections constituting the major functional areas of activity at the plant. These are: (1) pulp making, (2) paper and linerboard making, (3) chemical recovery, (4) by-products, and (5) electric power production. Flow diagrams were developed for each major functional area.

This approach will greatly simplify the diagrams and discussions by eliminating all but the major processes involved in addition to the numerous storage tanks located throughout the plant (some of which may hold several hundred thousand gallons of liquor, etc.). It is sufficient for our purposes to note that the plant produces approximately 1,450 total air dried tons of kraft paper and linerboard finished products per day. An air dried ton of finished product contains slightly less than 10 percent moisture. The plant was originally constructed to produce kraft paper. Several years later the kraft linerboard facilities were added. References in subsequent discussions to the number one paper machine or recovery system, etc., refers to the original facility. The number two

system is a completely separate operating unit.

The writer's general understanding of this exceedingly complex manufacturing system was gleaned largely from the study of Britt's Handbook of Pulp and Paper Technology[1] and the three-volume Pulp and Paper Manufacture[2] prepared under the direction of the Joint Textbook Committee of the Paper Industry. In addition, other books and articles relating to pollution problems in this industry presented descriptions of the productive processes that resulted in the particular environmental impact. Numerous discussions with plant personnel assisted in understanding the particular aspects of the mill studied.

Kraft Pulp Manufacturing Processes

The kraft sulfate process for pulping of wood was commercially developed in 1879 but it did not fare favorably in terms of costs, however, until the chemical recovery systems were developed in the mid 1930's. This marked the beginning of significant growth to its present dominant position in the industry.

Figure 1 on page 65 presents a diagram of the kraft pulp manufacturing processes. For nonintegrated pulp plants, this chart displays the total manufacturing system with the finished product, pulp, being shipped to customers rather than being further processed through the paper machines. Also shown, to illustrate how it fits into the total configuration, is a block depicting the chemical recovery system. The power plant, of course, serves the entire manufacturing facility.

Raw Material

The plant studied uses primarily wood chips from southern pine trees mixed with approximately 10 percent hardwood chips, which are

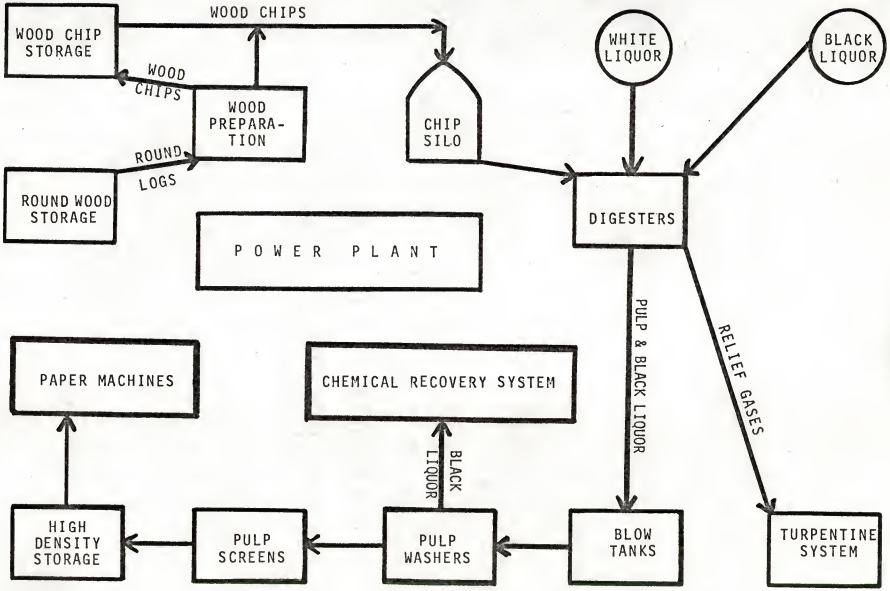

Figure 1

DIAGRAM OF KRAFT PULP MANUFACTURING PROCESSES

cheaper in cost. Some of the chips are purchased from a subsidiary of the plant but most are cut from five-foot roundwood logs received from company-owned timberland or purchased from tree farmers. The logs are conveyed by a water chute to rotating drums (8' diameter X 106' long) where the bark is knocked from the logs by the tumbling action as they gravity flow through the drums. The bark is conveyed to two combination boilers where it is combined with fuel oil and burned to produce steam.

The debarked logs are gravity fed against a large rotating chipper which cuts them into chips of specified size. Uniformity of chip size is important to the determination of the quality of the pulp. The chips are then conveyed to the chip silo or the storage yard.

Digesters

The plant utilizes the batch digester process which encompasses cooking wood chips in a liquor at certain temperatures and pressures for specified periods of time. The variables (chips, liquor, temperature, etc.) are predetermined depending upon whether the "cook" is for medium yield pulp for the number one paper machine or high yield pulp for the number two linerboard machine. The combination of chemical and physical forces is designed to substantially dissolve the lignin, which is the glue-like compound that holds the cellulose wood fibers together. At the end of the cook a brown colored pulp of cellulose wood fibers is suspended in a black liquor containing sodium caustic and sulfide plus the dissolved lignins and some organic sulfides. This liquor is subsequently washed from the pulp and stored for reuse or routed through the chemical recovery process. The cellulose fibers are separated when the pulp is blown under pressure from the digester to the blow pit, a process to be

more fully explained in the next section. Each digester blow produces approximately 14-15 tons of pulp.

Blow Tanks

When the batch of wood chips has been cooked for the specified length of time, the digester gases are released to bring the pressure in the digester to acceptable levels before the blow tank valve is opened. When this occurs, the remaining pressure blows the digester contents into the top of the blow tank where the pulp and liquor fall to the bottom.

The steam from the digester blow is routed through a heat accumulator where it is used to heat the water to wash the pulp. Some of the gases from the digester relief and blow escape to the atmosphere but most are carried to the turpentine production facilities.

Pulp Washing, Screening, and Storage

The pulp and liquor are pumped from the blow tank through a three-stage countercurrent brown stock washing process. The source of washing liquid for the last stage is fresh water that has been heated by the heat recovery system of the digester blowdown. By the time this liquid reaches the first stage of washers it is concentrated black liquor.

The washed pulp is routed through a screening process to remove clusters of fibers, oversized chips, and knots that would have a detrimental effect upon the quality of the finished product, if not removed.

As the pulp leaves the screening system it has a consistency of approximately one percent (i.e., it is approximately 99 percent liquid). It is then sent through a vacuum filtering system designed to remove enough liquid to increase its consistency to approximately 12 to 14 percent before being pumped to high density storage tanks. Large

integrated pulp and paper mills must have substantial pulp storage capacity to assure continuous operation in case of a major breakdown somewhere in the plant.

Kraft Paper and Linerboard Production

Figure 2 on page 69 shows a simplified diagram of the kraft papermaking and kraft linerboard-making processes. The paper produced at this plant is converted primarily into brown, grocery-type bags. The linerboard is used mainly to make cardboard boxes.

Pulp Preparation

Before raw pulp from the high density storage tanks is ready for the paper machine it is necessary to adjust its consistency to a relatively uniform 3-4 percent and process it through a refining system. The save-all vats change the high-density pulp to the desired consistency by mixing required amounts of white water from the forming section of the paper machine. This process also performs the function of reclaiming (saving) refined fibers that would otherwise be lost. Effluent overloads at the save-all vats are sewered to the river untreated.

The fibers in raw pulp are relatively long, smooth, and stiff. Paper prepared from this pulp would be unsuitable for most uses. The refining operation brushes and cuts the pulp fibers, increasing their bonding strength by increasing the bonding surfaces. This increases the quality of the finished product, i.e., tear strength, appearance, etc. There is a point of diminishing returns in pulp refining, however. Minimum refining is needed for the products produced at this plant.

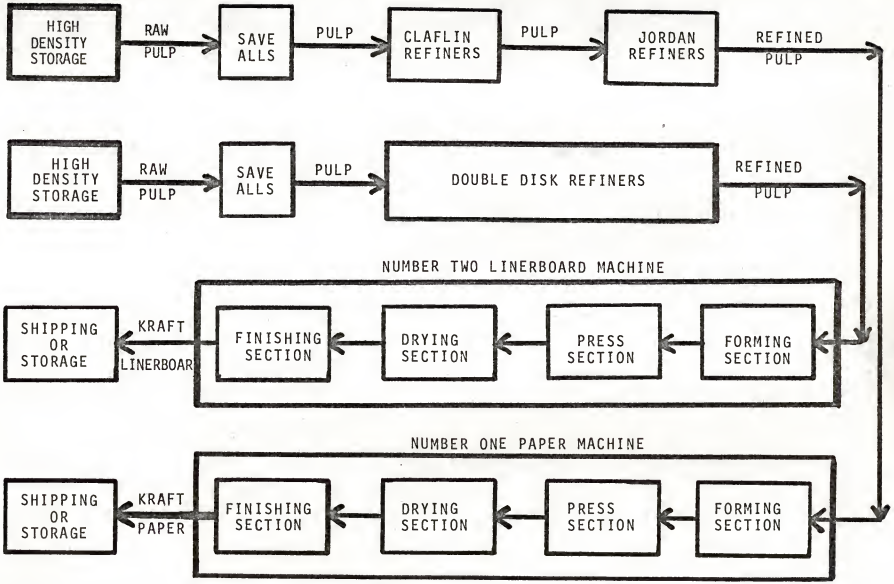

Figure 2

SIMPLIFIED DIAGRAM OF KRAFT PAPERMAKING AND KRAFT LINERBOARD MAKING PROCESSES

Paper and Linerboard Machines

Part of the finished product characteristics were determined by the variables set in the cooking of the pulp at the digesters. Other finished product features such as thickness, finish, printability, moisture resistance, etc., can be determined at the paper or linerboard machines. Most machines in use in the United States today evolved from a machine invented by Louis Robert in France in 1799. The Fourdrinier brothers of England acquired all rights to the machine in the early 1800's.

Forming Section

The basic step in the forming process is to provide a uniform and continuous flow of paper stock of approximately 0.5 percent consistency onto a moving wire mesh which permits the water to flow or be drawn through the wire, leaving an accumulation of fibers of approximately 25 percent consistency by the time it reaches the end of the machine. The thickness of the fiber sheet depends upon the variables that have been adjusted to produce the desired end product. Before the wire mesh is covered, however, significant quantities of fiber have fallen through the mesh. This fiber is carried by the drainage system, which underlies the entire forming section, into the white water reservoir where it is pumped to the save-all where the fibers are reclaimed, as previously noted. As the web of fibers reaches the end of the forming section, it is lifted and fed into the presses.

Controlling the many variables that can affect the finished product is truly a remarkable display of man's ingenuity. The delicacy of the operation can be easily imagined when it is remembered that these wire

meshes are up to 24 feet wide and are moving at speeds up to approximately 2,400 feet per minute (fpm).

Pressing and Drying Section

At the end of the forming section the fiber sheet has a consistency of approximately 25 percent, as previously noted. The bulk of the remaining productive process is directed toward increasing this consistency to over 90 percent. This operation begins in the pressing section.

The fiber sheet is picked up from the forming machine by a felt belt which feeds it through a series of steel rollers whose function is to physically squeeze as much water from the sheet as possible. In addition to conveying the paper sheet, the felt belts also absorb the moisture squeezed from the sheet. This requires a drying system for these belts. They must also be kept clean lest fiber accumulations damage the paper sheet. As the sheet leaves the presses it has a consistency of approximately 33 percent.

While the drying section of the paper machines merely continues the operation begun by the presses, the system is much more complicated and expensive. Two physical processes are involved. One is heat transfer; the other is mass transfer. Heat is transferred from a source, such as steam, through a cast iron cylinder wall to the sheet of paper to provide the energy necessary to effect the mass transfer, by evaporation.

Basically, the drying process involves running the sheet through a series of large (5 feet in diameter by approximately 20-24 feet long) hollow, cast iron cylinders that have had steam inserted into them under pressure. This steam heats the approximately one-inch thick cylinders uniformly and this heat is transferred to the paper sheet as it is

pressed against the cylinder by felt belts. As the sheet enters the spaces between the cylinders where it is free (i.e., is not in contact with the felt belt or the cylinder), the vapor pressure built up by the heat applied to the wet sheet can escape into the air adjacent to the sheet. To prevent moisture buildup in this space, thereby impeding the drying process, hot air is injected into the area on each end of the machine. The system is designed so that the paper sheet is heated on each side in an alternating pattern. By the time the paper reaches the end of the dryers, its moisture content has been reduced from approximately 67 percent to less than 10 percent.

The air supply and ventilating system plays an important part in determining drying rate and drying uniformity over the full width of the sheet. This can be seen when it is observed that for every ton of paper dried, two tons of water is evaporated and it takes between 50 and 60 tons of air to remove the water vapor. The hoods constructed over the paper machines have a system of vents and fans designed to remove the vapor-laden air to the atmosphere. Without an adequate ventilating system, not only would the paper drying process be impossible, but working conditions would be unbearable.

Finishing

As the sheet leaves the drying section it feeds into and through a vertical stack of rollers called a calender. As the machine section name indicates, the primary function of the calender is to provide the desired finished characteristics of the sheet in terms of both the smoothness of the sheet, the glossiness of the finish, and the caliper (thickness) of the sheet. A secondary function of the calender is to

correct for variations in the sheet (i.e., edges too thick, center too thick, etc.). Actually, this section offers the last opportunity to possibly alter undesirable features of the paper. Another secondary function that may be performed by the finishing section is to apply sizing solutions, color or special coatings to the sheet to give it desired characteristics.

As the sheets leave the calenders they are essentially finished products. The only remaining tasks are to wind them onto rollers and cut them into specific widths according to customer needs. When this is completed, the rolls are forwarded to storage or shipping departments.

Chemical Recovery Processes

In the discussion of the pulp washing section of the pulping process it will be recalled that this marked the beginning of the chemical recovery operation. The solution produced by the washing cycle is black liquor which is jet black in color, foamy in character, and contains dissolved lignin in the form of sodium salts of resinous and other organic acids in addition to almost 98 percent of the active alkali charged to the digester. The remaining two percent is lost in the pulp. Also contained in the black liquor are significant quantities of organic sulphur compounds in association with sodium sulphide plus some mercaptans. These sulphur compounds are the chief sources of the disagreeable odors affiliated with kraft mills. The basic purpose of the chemical recovery process is to replace the lost alkali in the black liquor, the end result of which is to convert the black liquor into white liquor ready for reuse in the digester.

Figure 3 on page 74 presents a diagram outling the steps involved

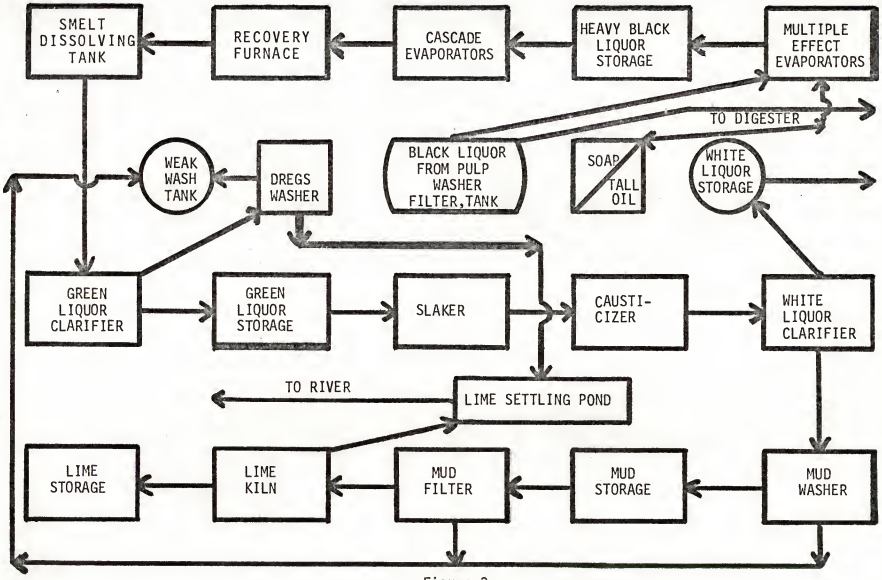

Figure 3

DIAGRAM OF CHEMICAL RECOVERY PROCESSES

in chemical recovery. A close examination of the flow chart reveals that two recovery systems are, in fact, in operation. The first, and most important, is the recovery of the alkali contained in the black liquor by converting it into white liquor. The second recovery system is the reclaiming of the lime used in the chemical conversion process. This system is illustrated in the bottom series of steps shown in Figure 3.

A review of Figure 1 on page 65 indicates that part of the liquor placed in the digester is raw, black liquor. The use of black liquor in the digester serves two purposes. It permits the attainment of the proper liquor-chips ratio without the use of additional white liquor or water. Furthermore, this procedure results in a higher concentration of organic materials in the black liquor which goes to the evaporators, thereby reducing the load on the chemical recovery system.

Multiple-Effect Evaporators

As the black liquor is washed from the pulp it has a consistency of approximately 13-14 percent. The function of the multiple-effect evaporators is to remove significant quantities of the liquid in the liquor, thereby increasing its consistency to approximately 50 percent.

The evaporators are long, vertical cylinders surrounded by tubes. The black liquor flows through the cylinders in one direction. Hot steam or vapor flows through the tubes in the opposite direction. The heat transfer from the steam or vapor goes to the liquor, thereby creating more vapor as the liquid in the liquor vaporizes as heat is applied to it. The multiple-effect evaporation comes from linking a series of these evaporators together.

The vapor from the last evaporator (i.e., the last in the series as

far as the steam-vapor flow) goes to a barometric condenser into which cooling water is sprayed. This condenses the vapor into a liquid which flows from the condenser creating the vacuum necessary to draw the hot vapors through the multiple-effect evaporator system. The source of the approximately 20 million gallons per day of cooling water and depository for the condensed effluent is the river adjacent to the plant.

The diagram shows a double arrow from the multiple-effect evaporators to a figure labeled soap/tall oil. Actually, as the liquor reaches a consistency in the range of 25-28 percent, approximately one-half way through the evaporator system, the foaming of the liquor has reached a point to where it would reduce the efficiency of the remaining evaporators unless removed. The foam is a resinous soap which is removed from the black liquor by causing it to flow through a device called a soap skimmer. Once the liquor passes through the skimmer it is returned to the evaporator system. This process increases the efficiency of the remaining evaporators in the range of 5 to 10 percent. The soap skimmings are subsequently processed to produce the by-product, tall-oil. This will be discussed further in a later section of this chapter.

Cascade Evaporators

The multiple-effect evaporators are indirect heat systems which means that the hot vapors or steam do not come into direct contact with the black liquor. In order to increase the consistency of the black liquor to the level required to support combustion in the recovery furnace (approximately 65 percent), further evaporation is necessary. This is accomplished by a direct contact evaporator system in which the liquor is brought into direct contact with hot flue gases that come from

the recovery furnace. Cascade evaporators consist of large vats into which the heavy black liquor flows. A series of wheels alternately dip into the liquor and emerge and rotate through the stream of hot flue gases. The agitation of the surface of the liquor plus the liquor attached to the wheels as they rotate produces the desired effect of evaporating additional liquid from the black liquor.

As the furnace flue gases leave the cascade evaporators, they go through electrostatic precipitators which remove most of the particles in the gas by electrical charges which attract them to metal plates. The particles are knocked loose (rapped) periodically and dumped back into the black liquor before it enters the cascade evaporators. The cascade evaporators also receive the spent acid produced in converting the soap skimmings produced in the multiple-effect evaporator system into tall oil in order that the chemicals contained in the spent acid may be reclaimed.

Recovery Furnace

The recovery furnace has two primary functions. The first is to burn the black liquor and salt cake that is sprayed into the furnace by jets. The make-up chemical, salt cake (sodium sulphate), is added to the black liquor prior to its injection into the furnace. The salt cake makes up for the active alkali lost in the pulping-chemical recovery systems. This amounts to approximately 100 pounds of salt cake per ton of pulp produced. The organic chemicals in the black liquor provide continuous combustion in the furnace once it has been ignited by an auxiliary fuel jet. The heat of the combustion reduces the sulphur containing compounds of sodium in the black liquor and the sodium sulphate of the salt cake to sodium sulphite in the form of a molten smelt that falls to

the hearth of the furnace where it drains to the smelt dissolving tanks.

The furnaces are square in shape and the walls consist of tubes with fins that are welded together to form a solid metallic interface with the interior of the furnace. Water flows through the tubes and is turned into steam by the heat of combustion in the furnace. The steam is pressurized and further heated by a superheater located in the top of the furnace. This pressurized, superheated steam is used in various locations throughout the plant or to turn turbines to generate electricity. This is the second function of the recovery furnace. The recovery furnace has been referred to as "the most 'prominent, expensive, and temperamental' piece of equipment in a kraft mill. It generates enormous energy, and is 'run on the ragged edge of an explosion.'"[3]

Smelt Dissolving/Green Liquor System

The smelt flowing from the hearth of the recovery furnace falls into a tank containing weak wash, which is a liquid effluent recovered from the green liquor dregs washer, mud washer, and mud filter. The smelt dissolves in the weak wash forming green liquor, a solution of sodium carbonate and sodium sulphide. The solution formed by the dissolved smelt must be agitated continuously by rotating, propellor-like blades to prevent an explosion by the highly volatile smelt reacting in the weak wash. The green liquor then flows through a multi-compartment, tray type clarifier where impurities, called dregs, are gravity settled from the liquor. These dregs are then pumped through a washer before being dumped in the lime settling ponds.

Slaker-Causticizer/White Liquor Clarifiers

The slaker is a large mixing tank with a motor-driven agitator where reburned lime or new make-up lime is added to green liquor. The first of a two-stage chemical reaction takes place in the slaker. The calcium oxide (CaO) of lime first reacts with water in the green liquor to form calcium hydroxide ($Ca(OH_2)$) producing considerable heat. After the reaction, undissolved impurities, called grits, gravity settle to the bottom of the tank where they are raked away and discharged to lime ponds or the river.

The green liquor that has been slaked with lime is pumped to causticizing tanks whose function is to hold the liquid for a sufficient time to allow the second chemical reaction to occur. In this reaction, the calcium hydroxide produced by adding lime to the green liquor reacts with the sodium carbonate in the green liquor to form sodium hydroxide (caustic soda). Any undissolved impurities remaining after the chemical reactions are pumped to the lime settling ponds.

After the second chemical reaction occurs in the causticizers the resulting liquid is white liquor. The only remaining step in the first chemical recovery process is to remove the undissolved lime mud and other impurities in the white liquor clarifier and the white liquor is ready for reuse in the digester.

Lime Mud-Washing, Storage and Filtering

The lime mud slurry that accumulates in the white liquor clarifier marks the beginning of the second chemical recovery process necessary in kraft pulping-paper operations. The function of the lime mud washing-storage-filtering sequence is to prepare the mud for incineration in the lime kiln, a process that reclaims the lime in a state that it can be

reused in the slaker. This function is accomplished by vacuuming the liquid (weak wash) from the mud increasing its consistency from approximately 35 percent as it leaves the white liquor clarifier to approximately 65 percent as it enters the lime kiln.

Lime Kilns

Physically, the lime kilns are long (up to 250'), steel, inclined, rotating cylinders (9' in diameter). Heat is provided at the lower, discharge end by fuel oil combustion producing temperatures approaching 2400^{o} F. Such high temperatures are necessary to burn the lime mud which is the kiln's function. The reburned lime is ready for use in the slaker. New lime for make-up is necessary due to the fact that 30 to 40 pounds of lime is lost for each ton of pulp produced.

By-Products

Two by-products were produced by the plant as the manufacturing system was operating at December 31, 1969. Both are members of the volatile oil extractives of wood and naturally emerge in the sulfate pulping processes.

Turpentine

Figure 4 on page 81 outlines the relatively simple process of obtaining turpentine from digester relief and blow gases.

The digester gases contain condensible gases (turpentine), non-condensible gases, and particles. The particles are separated first by centrifugal force and are carried to the sewer. The gases are then routed through a condenser where the condensible gases turn into liquid. This liquid, which is a mixture of water and raw turpentine, is

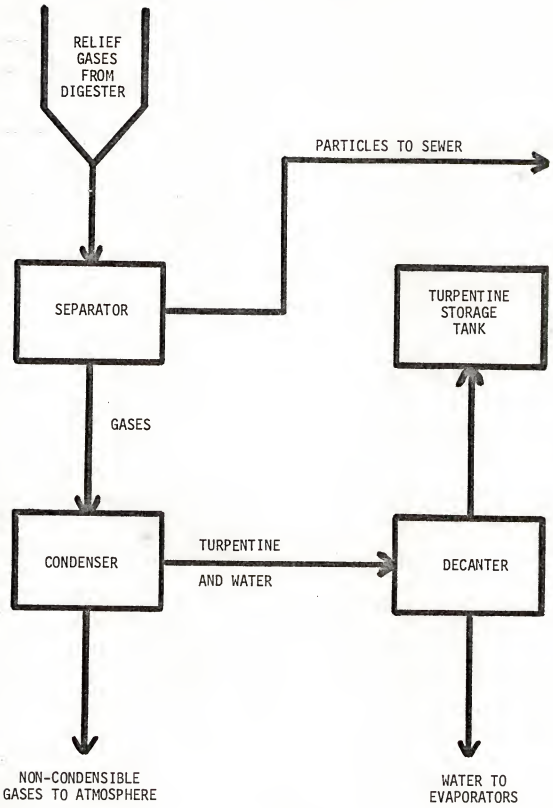

Figure 4

DIAGRAM OF TURPENTINE BY-PRODUCT PROCESSES

separated in a decanter where each seeks its own level according to their different specific gravities. Special piping drains the turpentine to storage tanks and the water to condensate tanks to be used in evaporators. The non-condensible gases are vented to the atmosphere.

Tall Oil

Figure 5 on page 83 presents a diagram of the tall oil by-product processes.

The soap skimmings removed from the black liquor are boiled in sulfuric acid producing tall oil, spent acid, lignins, and other impurities. The tall oil is separated from the undesired chemicals in the centrifuge where differences in specific gravities and special piping cause each to flow to different storage tanks. The unwanted chemicals are pumped to the cascade evaporators to be added to the black liquor for chemical reclamation purposes.

Power Plant

Large, integrated pulp and paper mills, such as the one studied, consume substantial quantities of electricity in their operations. As a result, most of them have facilities to generate all, or a substantial majority, of their power needs.

Electric power plants have a significant environmental impact as previously noted. How significant depends upon the sulfur content of the fuel burned and any supplemental fuel used, such as bark which may materially increase particulate emissions. Also, recovery boilers, which burn black liquor, have their own types of emissions to be considered.

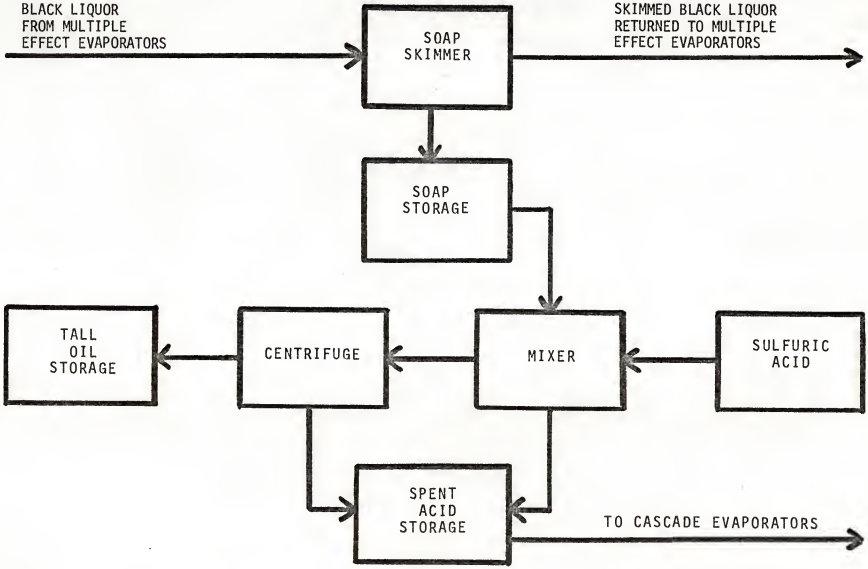

Figure 5

DIAGRAM OF TALL OIL BY-PRODUCT PROCESSES

Figure 6 on page 85 presents a simplified diagram of the power generating facilities located at the mill. All of the boilers are regulated to produce steam at 600 psi pressure and 750° F. temperature. All of the steam flows into a system of steam headers which are cylinders joined together by pipes and valves. Steam can be extracted anywhere along the header system to be fed to the turbines.

Substantial quantities of steam (approximately 7 billion pounds) are drawn off for direct use in the mill each year, primarily at the digesters and paper machine dryers. Significant quantities of steam flowing to the number 2 and 3 turbines is condensed back into liquid to be used as feedwater for the boilers. The balance of the steam is used to turn the turbines to generate electricity. Approximately 50 million gallons per day (mgd) of water is used to cool the turbines after which it is sewered back to the river.

Purchased electricity in 1972 and 1973 accounted for only 8 percent of total needs but this source rose to 14 percent in 1974, primarily because of operation of additional pollution abatement facilities.

Summary

The objective of Chapter 3 has been to present flow diagrams and brief, non-technical descriptions of the manufacturing processes utilized in a large, integrated pulp and paper mill. The purpose of the chapter is to enable the reader to obtain a general understanding of the productive facilities in order that he may relate subsequent discussions of pollution points, estimates, abatement facilities acquired and in-plant changes made to the various areas of operations.

The plant studied originally produced only kraft paper used

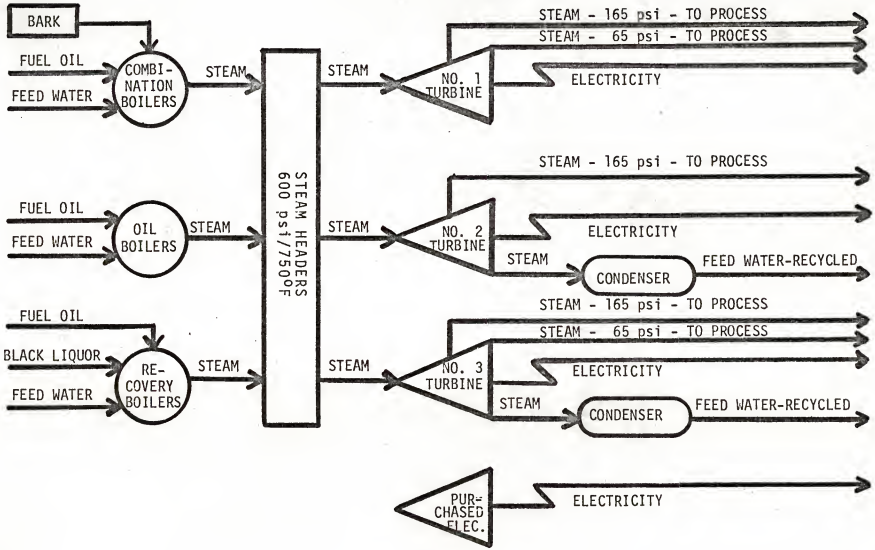

Figure 6

SIMPLIFIED DIAGRAM OF POWER GENERATING FACILITIES

primarily to make brown, grocery-type bags. Several years after the original plant was built, a larger facility was added to make kraft linerboard used principally to produce cardboard boxes. The combined daily output is generally 1,450 tons of finished product.

The manufacture of wood pulp by cooking wood chips in an alkaline solution is the finished product of some mills. At the plant studied it is the raw material that is processed through the paper or linerboard machines to produce the product ready for shipment to customers. Two raw material recovery systems are also in operation at the plant. One recovers the alkali from the pulp cooking liquor. The other recovers the lime used in the first chemical recovery system. One by-product is crude turpentine which is extracted from gases produced during the pulp manufacturing process. Another by-product, crude tall oil, is produced in the chemical recovery system. Both by-products are sold to other firms for further processing. The plant also has a complete power generating system which has significant environmental impacts.

NOTES

1. Britt, Kenneth W., ed., Handbook of Pulp and Paper Technology, Second Edition (New York: Van Nostrand Reinhold Company, 1970).

2. MacDonald, Ronald G., ed., Pulp and Paper Manufacture, Second Edition, Three Volumes (New York: McGraw-Hill Book Company, 1969).

3. Allan op. cit., 22.

CHAPTER IV

POLLUTION: SOURCES, ESTIMATES AND ABATEMENT

Chapter 3 diagrammed and explained the manufacturing processes and power plant facilities of the mill studied. On a number of occasions references were made to gases and particulates emitted to the atmosphere and liquid effluents sewered to the river adjacent to the plant. The first objective of the present chapter is to list these pollution points together with quantitative estimates of pollutants produced by the facility's operations. The second objective of the chapter will be to identify and briefly describe any pollution abatement facilities in existence at December 31, 1969, the date as of which the manufacturing configuration was discussed in Chapter 3. A condensed flow diagram of the plant showing the location of the pollution points and abatement facilities will be presented. The final chapter objective will be the identification and explanation of abatement facilities acquired, and in-plant modifications made, for the five years ended December 31, 1974. Flow diagrams emphasizing these abatement facilities and in-plant changes will be presented as will tables showing revised quantitative estimates of pollution impacts.

Pollution Sources and Estimates

Until very recently there were no requirements concerning the monitoring of pollution quantities at manufacturing facilities. As a

result of this state of affairs, the technology in this area is not well developed. Hendrickson makes this point when he states that "Most of the methods (sampling and analytical techniques) applicable to both sources in the mills and the ambient air must be considered research methods in a state of evolution at this time."[1] In order to estimate the magnitude of the plant's physical impact upon the environment it will be necessary to use data from studies conducted upon mills having the same general technological configuration as those used by the facility under examination.

It is well to recall at this point that the concern is with the productive facilities impact upon the environment. Any minor localized emissions or impacts from overflows, leakages, breakages, etc., are ignored.

Air Pollutants

Before proceeding to accomplish the first of the assigned tasks, a brief discussion of the principal pollutants themselves is in order. It will be recalled that Dworsky divided air pollutants into two broad classes, particulates and gases.

Particulates are solid particles or droplets of liquid which may be discharged into the atmosphere by the productive processes. Those from a kraft pulp and paper plant consist primarily of sodium sulfate, sodium carbonate, sodium salts, calcium carbonate, calcium sulfate, calcium oxide, insoluble ash, and small droplets of black liquor.

The primary gas emissions from a kraft pulp and paper mill are sulfur dioxide (SO_2), hydrogen sulfide (H_2S), methyl mercaptan (MeSH), dimethyl sulfide (MeSMe), and dimethyl disulfide (MeSSMe). The presence of sulfur in the cooking compound reacting with the wood chemicals (primarily lignin) and subsequent combustion and oxidation of the liquor in the recovery process produces most of these compounds. The sulfur

content accounts for the obnoxious odors associated with these plants.

Air Pollution Points and Estimates

The study used to recognize and estimate the physical impact of the plant upon its air environment is the three-volume Control of Atmospheric Emissions in the Wood Pulping Industry by Hendrickson, Roberson and Koogler, previously cited. The authors present ten flow diagrams of the kraft pulping and chemical recovery processes, each assuming a different production configuration, abatement facilities, mill age, and finished product mix.

Flow diagrams 1[2] and 5[3] substantially represent the plant studied. The assumed age of these mills is over 15 years (the date of the transmittal of the study was March 15, 1970). They are located in the Southern United States and purport to represent approximately 30 to 40 mills. Diagram factors include: batch digesters, no black liquor oxidation, direct contact evaporators, no bleaching, moderate collection efficiency of lime kiln scrubbers, long tube vertical (multiple effect) evaporators, and softwood as raw material. It is felt that the small percentage of hardwood chips used at the plant studied will have no significant effect upon the representative emissions as presented in the Hendrickson study.

Hendrickson's diagram 1 is for a mill producing base linerboard stock, whereas diagram 5 is for top liner. This diagram also represents the kraft paper production of the mill studied as the only difference between the kraft paper and top liner is the thickness and finish of the sheet. Both are made from the same pulp.

Table 1 on page 92 displays the sources and estimated quantities of air pollutants from a kraft mill producing base stock pulp used in making linerboard. Table 2 on page 93 shows the sources and estimated quantities of pollutants from a kraft plant producing top liner and paper. The quantities shown are pounds per ton of air dried pulp produced. An air dried ton of pulp contains approximately 10 percent moisture.

These tables were developed from the Hendrickson study. Only one modification of quantities was made in Table 2. This was necessary because the assumption in the Hendrickson study was mechanical scrubbers on the lime kiln with an 80 percent efficiency rating. The lime kiln at the plant studied had a Venturi scrubber. At December 31, 1969, this unit was approximately 3 years old. At this point it was operating at approximately 90 percent efficiency per plant engineers. The emissions from the lime kiln were adjusted to reflect the higher efficiency scrubber. The only other modification was to total the columns. This will facilitate subsequent revision of the quantities, if necessary. If revisions are not necessary, then the totals will assist in the computation of pollution quantities to be included in the Environmental Impact Report.

Table 3 on page 94 was developed to portray the air emissions emanating from the bark combination boilers and the fuel oil boilers. The presentation is in pounds of sulfur dioxide (SO_2) and fly ash (particulates) produced per 1,000 pounds of fuel burned. The starting point for this table was a table given in Hendrickson[4] which assumed fuel oil with a 2 percent sulfur content. In view of the fact that the plant studied was subject to more stringent laws, it was necessary to adjust the emissions for the fuel oils with lower sulfur contents. Also shown are the dates for whith the sulfur content requirements were in effect.

The only other adjustment made in the quantities was to average the ranges shown in the Hendrickson table to arrive at absolute estimates that can be used in developing data for the Environmental Impact Report.

Table 1

ESTIMATED POUNDS OF EMISSIONS PER AIR DRIED TON OF KRAFT LINERBOARD PULP PRODUCED

Location	H_2S	MeSH MeSMe MeSSMe	SO_2	Particulates
Blow Tank Accumulator	0.10	2.90	0	0
Washers and Screens	0.01	0.12	0	0
Multiple Effect Evaporators	0.50	0.40	0	0
Recovery Boiler and Direct Contact Evaporators-- After Precipitators	10.70	1.40	3.50	9.80
Smelt Dissolving Tank	0.02	0.05	0	4.00
Slaker	0	0	0	Unknown
Lime Kiln Scrubbers	0.48	0.50	Trace	4.30
Turpentine Condensers	0.01	0.51	0	0
Totals -- After Precipitators and Scrubbers	11.82	5.88	3.50	18.10

Source: Adapted from Hendrickson, E. R., J. E. Roberson, and J. B. Koogler, Control of Atmospheric Emissions in the Wood Pulping Industry, Volume I (Gainesville, Florida: Environmental Engineering, Inc., and Greenville, S. C.: J. E. Sirrine Company, March, 1970), 3-14 and 3-15.

Table 2

ESTIMATED POUNDS OF EMISSIONS PER AIR DRIED TON OF KRAFT TOP LINER AND PAPER PULP PRODUCED

Location	H_2S	MeSH MeSMe MeSSMe	SO_2	Particulates
Blow Tank Accumulator	0.12	3.35	0	0
Washers and Screens	0.02	0.17	0	0
Multiple Effect Evaporators	0.50	0.31	0	0
Recovery Boilers and Direct Contact Evaporators--After Precipitators	14.60	1.50	4.80	11.00
Smelt Dissolving Tank	0.04	0.05	0	4.00
Slaker	0	0	0	Unknown
Lime Kiln Scrubber	0.20	0.12	Trace	5.10
Turpentine Condenser	0.01	0.50	0	0
Totals--After Precipitators and Scrubbers	15.49	6.00	4.80	20.10

Source: Adapted from Hendrickson, E. R., J. E. Roberson, and J. B. Koogler, Control of Atmospheric Emissions in the Wood Pulping Industry, Volume I (Gainesville, Florida: Environmental Engineering, Inc., and Greenville, S. C.: J. E. Sirrine Company, March, 1970), 3-31.

Table 3

ESTIMATED SULFUR DIOXIDE AND FLY ASH EMISSIONS
FROM VARIOUS FUELS BURNED IN POWER BOILER
(Pounds per 1,000 Pounds Fuel Burned)

Fuel	Period Used	SO_2	Particulates (Fly Ash)
Bark	-	1.25	15
Oil (1.5% Sulfur)	8/69- 8/70	30	0.7875
Oil (1.0% ")	8/70-11/71	20	0.475
Oil (1.8% ")	11/71- 6/75	36	0.855

Source: Adapted from Hendrickson, E. R., J. E. Roberson, and J. B. Koogler, Control of Atmospheric Emissions in the Wood Pulping Industry, Volume I (Gainesville, Florida: Environmental Engineering, Inc., and Greenville, S. C.: J. E. Sirrine Company, March, 1970), 4-60.

Water Pollutants

In spite of substantial water reuse facilities in existence at the mill studied, approximately 90 million gallons per day (MGD) of liquid effluents is discharged to the river. All of this liquid leaves the plant through a common sewer and it is significantly contaminated in terms of its effect upon the receiving waters. Water pollutants are generally discussed in terms of suspended solids, dissolved solids, biochemical oxygen demand, pH factor, and heat.

Suspended solids consist of grit or sand, small pieces of bark, wood fibers, and some undissolved chemicals (lime, salts, etc.). These solids will usually gravity settle from the liquid if it is permitted to remain still for a sufficient period of time. Those that are capable of being degraded by microorganisms in the receiving waters will eventually be consumed by this natural phenomenon. Those particles that

will not dissolve eventually come to settle in the water basin, possibly smothering plant life, thereby reducing the food supply of the waters.

Dissolved solids are generally chemicals that will be diluted by the receiving waters and consumed by the bacteria, if organic. Excessive bacterial activity necessary to assimilate the mill wastes consumes the oxygen in the receiving waters (biochemical oxygen demand) to the extent that higher forms of aquatic life cannot survive.

McGauhey states that "As a measure of this oxygen demanding property of a waste in water a biochemical oxygen demand (BOD) test has been developed and is perhaps the best known measure of water quality in the world . . . Within quite acceptable limits of definition it may be said that the 'ultimate BOD' of an organic waste is the amount of oxygen required by microorganisms (bacteria) . . . in reducing organic matter to stable compounds."[5]

The pH factor of a solution is a symbol of its acidity or alkalinity. Solutions with pH values from 0 to 7 indicate acidity, whereas pH values from 7 to 14 indicate alkalinity. Nemerow notes that "It is generally agreed that the pH of a stream must be not less than 4.5 and not more than 9.5 if fish are to survive."[6]

Thermal pollution occurs when cooling waters are sewered at temperatures significantly higher than those of the receiving waters. If the flow is substantial, then the effect can be felt far from the point of discharge. The warmer water promotes the growth of bacteria possibly eliminating higher species of aquatic life from the area.

Water Pollution Points and Estimates

Table 4 on page 96 presents a listing of sources of effluents from a kraft pulp and paper mill. The percentage of the total from each

source is listed as is the average pH factor associated with each source. The table was developed from one included in The Cost of Clean Water, Industrial Waste Profile No. 3, Paper Mills III[7] prepared by the Federal Water Pollution Control Administration. The table selected presented the results of studies of mills representing the majority of existing (1967) productive facilities utilizing "today's typical technology."

Table 4

PERCENTAGE OF EFFLUENTS AND AVERAGE pH FACTORS FROM VARIOUS SOURCES IN A KRAFT PULP AND PAPER PLANT UTILIZING TODAY'S TYPICAL TECHNOLOGY

Processes	% Solids	% BOD	Average pH
Wood Preparation	3.0	4.7	7.0
Pulping:			
Blow Tank	4.8	2.0	12.0
Dirty Condensate	1.6	12.5	10.0
Causticizing Waste	23.2	14.0	10.0
Floor Drain	5.0	1.5	12.0
Pulp Screening	2.5	1.5	12.0
Pulp Washing & Thickening	32.6	38.9	9.0
Paper Making	27.3	24.9	5.0
Totals	100.0	100.0	

Source: U. S. Department of the Interior, The Cost of Clean Water--Industrial Waste Profile No. 3--Paper Mills (Washington, D. C.: Federal Pollution Control Administration ,1967).

The subprocesses used to classify a mill in this category were primarily the same as those used by the mill studied (i.e., mechanical debarking,

bark utilization, batch digesters, etc.). The only source listed in Table 4 not outlined in the discussion of the productive processes is floor drains. Underlying the entire mill is a drainage system which permits spills and overflows to be sewered rather than having to be picked up by hand or portable mechanical pumps.

Table 5 below portrays the impact of the plant's effluent upon the receiving river. The organic base load is expressed in pounds of BOD per day. BOD, it will be recalled, is the best known measure of a pollutant's effect upon receiving waters. These quantitative estimates were taken from a comprehensive engineering study[8] made for the purpose of developing design parameters for the water treatment facility the firm was planning. The base year of the study was 1969.

The firm had been directed by the Florida Department of Air & Water Pollution Control to effect a 90 percent removal of the untreated organic load in the plant's wastewater by January, 1973. This requirement indicates that the allowable BOD discharge to the river is approximately

Table 5

ORGANIC BASE LOAD OF KRAFT
PULP AND PAPER PLANT

Source	Lbs. BOD Per Day
BOD	120,400
Organic Settleable Solids	249,900
Bark	1,900
Total Organic Base Load	372,200

37,200 pounds BOD per day. Monitoring devices must indicate that this quantity is not exceeded more than 10 percent of the time.

Figure 7 on page 99 presents a condensed diagram of the manufacturing plant studied. Omissions from previous diagrams are primarily the numerous storage tanks located throughout the mill. The paper machine operations were also consolidated. The symbols in Figure 7 indicate the location of pollution points at the plant at December 31, 1969. Also symbolized are the location of abatement facilities in existence at that point in time. These will be discussed in the next section.

Pollution Abatement Facilities

Table 6 on page 100 lists the pollution abatement equipment in operation at the plant at December 31, 1969. Two columns are provided for the amounts capitalized according to the Job Order Purchase Authorization (JOPA) forms. Those facilities acquired for economic benefits (chemical recovery or by-product production) are shown in the capital investment column even though the environment may benefit from their operation. The cost of equipment acquired for pollution abatement capabilities with little or no economic benefits are shown in the social investment column.

Electrostatic Precipitators

A review of Tables 1 and 2 indicates that the function of the electrostatic precipitators is to remove the particulates trapped in the gases. This is done at an approximately 90 percent efficiency rate. The gases, however, are not trapped but are vented to the atmosphere.

The electrostatic precipitator is a large, square container through

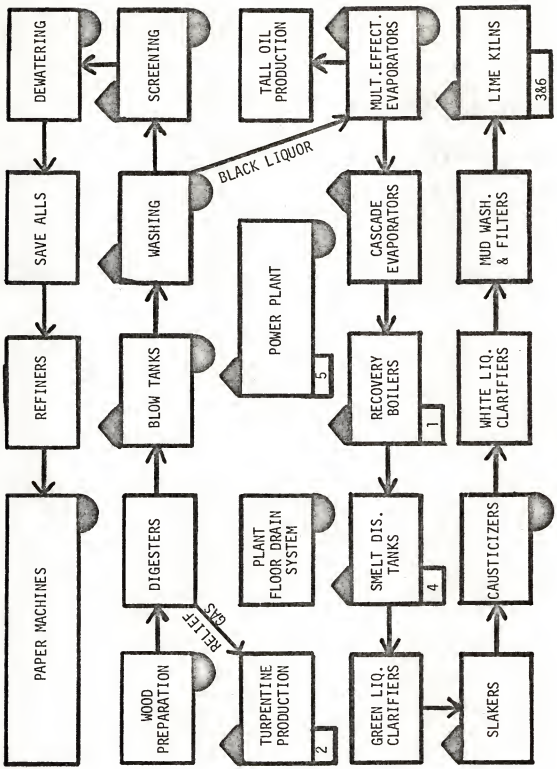

Figure 7

CONDENSED DIAGRAM OF PULP, PAPER, AND LINERBOARD
PLANT INDICATING LOCATION OF POLLUTION SOURCES AND ABATEMENT FACILITIES

Table 6

POLLUTION ABATEMENT EQUIPMENT IN OPERATION
AT DECEMBER 31, 1969

No.	Year Installed	Description	Location	Capital Investment	Social Investment
1	1953	Electrostatic Precipitators (2)	No. 1 Recovery Boiler	$ 643,802	
2	1953	Heat Exchange Condenser	No. 1 Turpentine System	17,086	
1	1957	Electrostatic Precipitators (2)	No. 2 and No. 3 Recovery Boilers	705,133	
2	1957	Heat Exchange Condenser	No. 2 Turpentine System	36,881	
3	1957	Peabody-Tray Type Dust Removers(2)	No. 2 and No. 3 Lime Kilns		$ 31,828
4	1965	Steel Mesh Demisters (3)	Smelt Dissolving Tanks		20,697
5	1967	Mechanical Collectors (2)	Combination Boilers	357,357	
6	1967	Venturi Scrubber	No. 1 Lime Kiln		86,190
	Totals			$ 1,760,259	$ 138,715

which the gases are made to flow between a series of chambers made up of discharge electrode and collecting electrode plates. The particles become negatively charged as they pass through the chambers and attach themselves to the collecting electrode plates. Rapping devices knock the accumulated particles from the plates, causing them to gravity feed back to the black liquor for chemical recovery purposes.

Heat Exchange Condenser

Small amounts of hydrogen sulfide and reduced sulfur compounds are included among the gases from the digester relief and blow. These gases are non-condensable. Also included are condensable gases which are essentially crude turpentine together with trapped particles. These hot gases flow through a condenser chamber filled with tubes through which cold water runs. The difference in temperature (heat exchange) of the cool surface of the tubes and the gases causes the condensable gases to turn into a liquid which flows through the remainder of the turpentine production system. The non-condensable gases are vented to the atmosphere. It is estimated that the heat exchange condenser removes slightly over 90 percent of the condensable relief gases.

Peabody Tray Type Dust Removers

The function of the dust removers attached to the stacks of the number 2 and number 3 lime kilns is to capture the dust particles entrapped in the lime kiln flue gases. The amount at Tables 1 and 2 indicate that small quantities of other gases are also eliminated in the process.

The Peabody dust removers are cylinders in which trays are located. As the hot gases feed into the bottom of the cylinder they pass through

a series of showers at the trays. The difference in the velocities of the gases causes them to collide, entrapping most of the dust particles and some gases in liquid droplets. This liquid gravity feeds to the sewer while the remaining gases and particles are vented to the atmosphere. The efficiency of these units is relatively low (approximately 90 percent) and as a consequence both had to be replaced with more efficient Venturi scrubbers in 1970 and 1971.

Steel Mesh Demisters

Attached to the vents of the smelt dissolving tanks are knitted wire mesh pads through which all of the gases in the tank must flow before reaching the atmosphere. The function of the pads is to trap particles and liquid droplets entrained in the gases. A backwash shower washes the pads and the liquid flows back into the tank. The recovery is such, however, that the devices would not be installed except to meet the requirements of the state pollution control agency.

Mechanical Collectors

Combination boilers have traditionally been a significant source of particulate emissions from a pulp and paper plant. This stems primarily from the nature of the materials being burned, pine bark in combination with fuel oil.

In 1967 both boilers were extensively rebuilt to improve their operation, which is the greatest factor in determining the quantities of pollutants that flow from the boilers. Included in the rebuilding were new 8-cylinder dust collectors on each boiler. The hot gases from the boiler with the entrapped particles flow horizontally into the series of vertical cylinders. The force of the velocity of the gas flow entering

the round cylinders causes the gas to flow in circles. The heavier particles are thrown against the walls of the cylinders by centrifugal force where they fall from the collector by gravity. The charred particles were originally reinjected into the system. Later they were sold to make charcoal briquets.

Venturi Scrubbers

Venturi scrubbers are highly efficient devices for removing particulates from gas streams. The principle of operation is to feed the dust-laden gas stream through a washing liquid spray and then through a series of convergent and divergent sections and elbows. The difference in velocity of the gas and liquid plus the rapid changes in velocity in the scrubber itself causes collisions and aggregations of the moisture entrained particles. The stream then enters the separator cylinder at a tangent where the cyclone effect throws the liquid against the side of the tank where it gravity flows from the Venturi. The cleaned gases escape to the atmosphere.

The original mechanical dust collector on the number one lime kiln was replaced by the Venturi scrubber in 1967. Venturi scrubbers operate at an efficiency level of approximately 99 percent for removal of particulates from lime kiln gases.

Abatement Facilty Acquisitions and In-Plant Changes

This section of the present chapter of the research project will be directed to scheduling and briefly explaining any in-plant changes and pollution abatement facilities acquired during the 5-year period ended December 31, 1974. This listing is presented in Table 7 on page 104.

Table 7

POLLUTION ABATEMENT FACILITIES ACQUIRED AND IN-PLANT PROCESS CHANGES MADE -- FIVE YEARS ENDED DECEMBER 31, 1974

Date	Description	Location	Capital Investment	Social Investment
6/70	Venturi Scrubber	No. 3 Lime Kiln		$ 119,508
7/70	Turpentine Recovery Modification	Turpentine Systems	$ 64,443	
2/71	Low Sulfur Fuel Oil Facility	Power Plant		140,632
9/71	Venturi Scrubber	No. 2 Lime Kiln		137,539
12/71	In-Plant Changes--Phase 1	Plant		367,982
10/72	Wastewater Treatment Facility and In-Plant Changes--Phase 2	Plant		5,541,341
10/72	13.8 KV Electric Powertie	Waste Treatment Facility		248,774
12/73	No. 2 Heat Accumulators	Digesters		269,310
7/74	TRS Monitoring Instrumentation	Recovery Boilers		18,746
10/74	In-Plant Changes--Phase 3	Plant		528,603
12/74	No. 1 Heat Accumulator	Digesters		126,966
12/74	Varkus Scrubber	No. 3 Recovery Boiler		917,836
12/74	Recovery Boiler Modifications	Recovery Boilers		712,382
12/74	Venturi Scrubber Modifications	No. 1 Lime Kiln		16,309
12/74	TRS Monitoring Instrumentation	Recovery Boilers		5,459
	Totals		$ 64,443	$ 9,151,387

Figures 8, 9, and 10 on pages 106, 107, and 108, respectively, show revised flow diagrams which emphasize the location of the abatement facilities acquired and in-plant changes made during this period.

Venturi Scrubbers

In June of 1970 and September of 1971 the plant completed installation of Venturi scrubbers on the number 3 and number 2 lime kilns, respectively. The operation of this apparatus was explained previously and no additional comments are needed here.

The Venturi scrubber on the number 1 lime kiln (installed in 1967) required modifications to upgrade its efficiency. This was completed in December, 1974. The modifications were primarily reinforcement plates at the elbow of the scrubber to permit higher gas and water velocities.

Turpentine Recovery Modifications

Additional condenser capacity with related separators and decanters were added to the turpentine recovery system in July, 1970. The function of the expenditure was to increase the turpentine yield from the relief gases with a payback in less than two years, according to the JOPA. The modifications did slightly reduce the flow of TRS gases to the atmosphere according to plant personnel. However, since no monitoring devices were utilized and the reduction is only "slight," no reduction will be made in the estimated emissions from this source in the Environmental Impact Report computations.

Low Sulfur Fuel Oil Facility

The requirement that the mill begin using 1 percent sulfur content fuel oil by September 1, 1970, necessitated expenditures to heat the fuel oil lines and insulate the storage tanks to handle this special oil. The

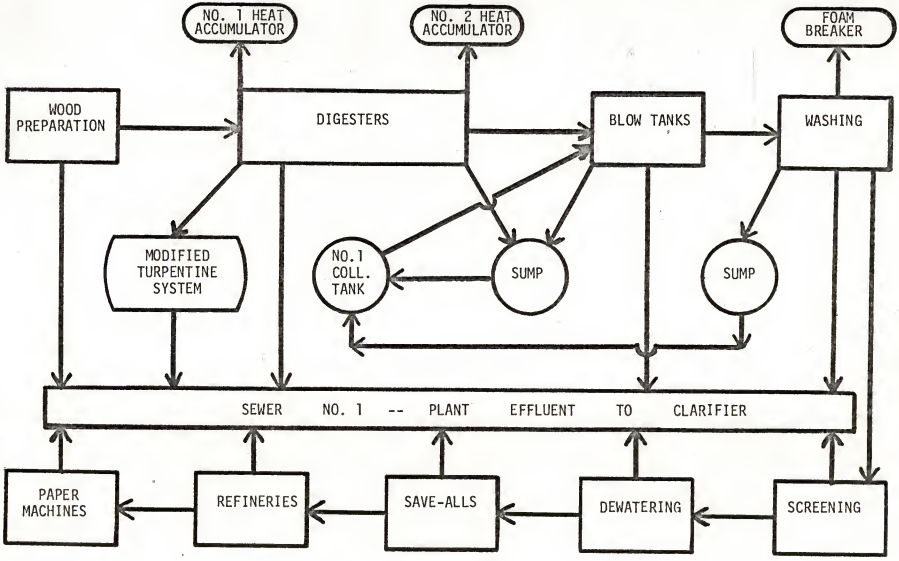

Figure 8

REVISED FLOW DIAGRAM OF PULP AND PAPER PLANT SHOWING
POLLUTION ABATEMENT FACILITIES ACQUIRED OR IN-PLANT CHANGES MADE

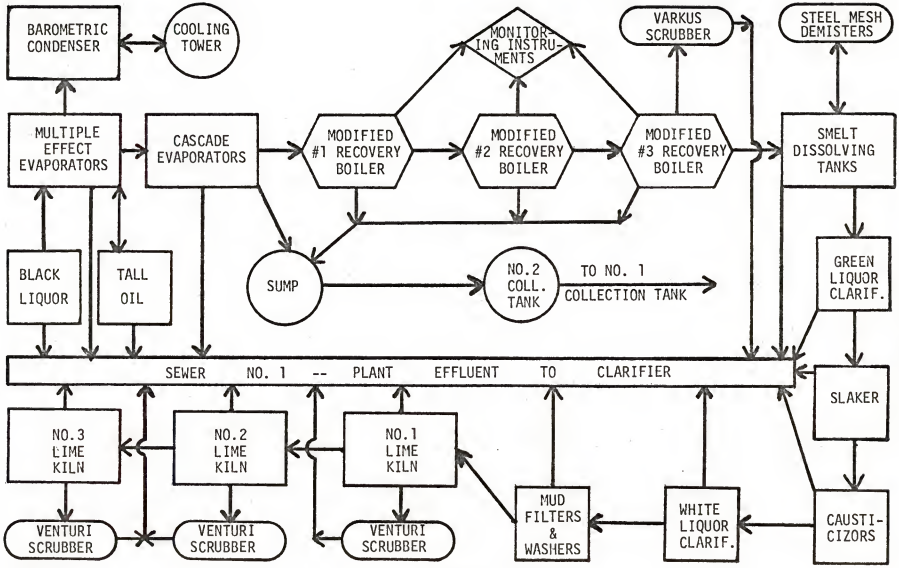

Figure 9

REVISED FLOW DIAGRAM OF KRAFT PULP AND PAPER PLANT CHEMICAL RECOVERY SYSTEM
WITH EMPHASIS ON POLLUTION ABATEMENT FACILITIES ACQUIRED OR IN-PLANT CHANGES MADE

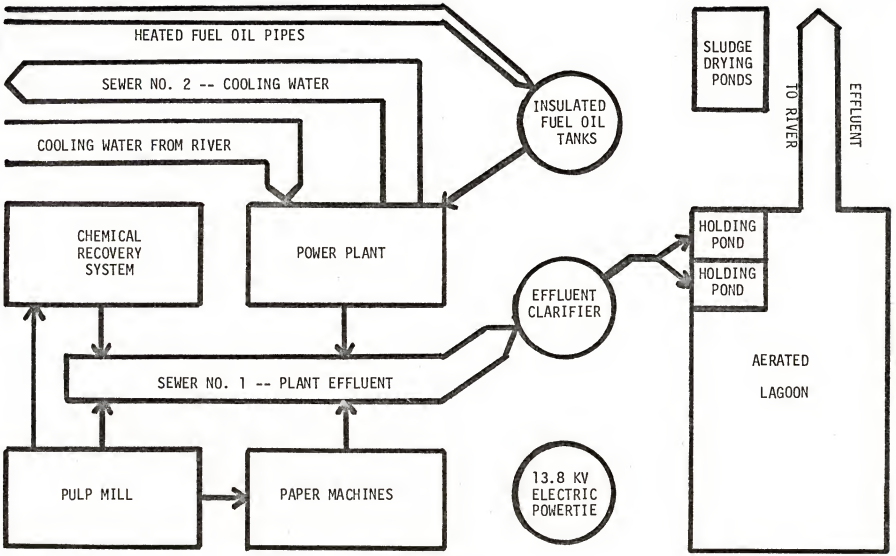

Figure 10

REVISED FLOW DIAGRAM OF KRAFT PULP AND PAPER PLANT
EMPHASIZING POLLUTION ABATEMENT FACILITIES ACQUIRED OR IN-PLANT CHANGES MADE

problem stems from the fact that fuel oil with this low a sulfur content will not pour or flow unless its temperature exceeds 110^{0} F.

Phase I In-Plant Changes

Expenditures for the first of three phases of in-plant changes mark the beginning of a water control program at the mill that will cost approximately $6.7 million by the time it is completed.

Previous discussions indicated that all of the plant's process effluent and all of the cooling waters for condensers flowed into two sewer lines which converged into one 72-inch outfall line before discharge to the river.

The function of the phase one in-plant changes is to separate the number 1 sewer line so that it would receive only the process waste effluent from the plant. All of the cooling water is to be routed through the number 2 sewer line. The purpose of this change is to significantly reduce the flow to the waste treatment facilities to be constructed.

Waste Treatment Facilty and Phase II In-Plant Changes

The phase 2 in-plant changes provided for construction of a cooling tower for the barometric condenser, making this a closed system. This reduced the flow of heated water to the river by approximately 20 MGD. One effect of the change is to enable the plant to more easily attain possible future restrictions on thermal effects on receiving waters. Any barometric condenser make-up water required due to evaporation comes from the mill effluent. This feature plus the oxidation of the organic materials by the cooling tower reduced the load on the waste treatment facilities.

The primary wastewater treatment system is designed to remove approximately 80 percent of the total suspended solids and 99+ percent of the settleable solids from the approximate 18 MGD mill effluent flow. The effluent gravity flows to the 225-foot diameter, 15-foot sidewall depth clarifier. Here it remains for over 5 hours during which time the solids gravity settle to the bottom. The solids are scraped to a central sump (concrete lined hole) from which they are pumped through a vacuum filter dewatering system. The sludge is hauled by truck to plant site landfill areas while the liquid is returned to the clarifier. After the detention period, the effluent gravity flows to the secondary treatment facility.

The secondary wastewater treatment facility consists of 2 holding ponds each 3½ acres in size and 10 feet deep, with a capacity of 10 million gallons and a 60-acre, 10-foot deep aeration lagoon capable of retaining the effluent for 10 days before discharging it to the river.

The holding ponds are generally used as a back-up facility to the clarifier and provide an additional settlement of solids before the effluent enters the aerated lagoons. The holding ponds may also be used simply as storage facilities for whatever period necessary for good system operation.

During the 10-day retention period in the lagoon, bacteria and algae decompose the biodegradable materials in the effluent. Fifteen aerators provide additional oxygen in the lagoon. Without this feature, the lagoon would have to be considerably larger in order to hold the effluent for sufficient time to permit natural decomposition to occur (several months). After the holding period, the effluent flows to the river.

The system also has sludge holding ponds next to the lagoon which

serve as depositories of the sludge dredged from the holding ponds. The liquid effluent is pumped back to the lagoon while the sludge is permitted to dry. After drying it is used as landfill at the plant site.

Parshall flumes are monitoring devices which permit measurement and analysis of the effluent flow. One is located before the clarifier; one is placed after the clarifier; and one is located after the secondary treatment facility. Their function is to measure the BOD, pH, and temperature of the effluent to determine if the total wastewater control program of the plant meets pollution control standards.

Number 1 and Number 2 Heat Accumulators

The discussion in Chapter 3 revealed that the heat from the digester blow downs was captured in the heat accumulators and used to provide hot water for washing the pulp. The capacity of this device was based upon hot water needs with excess steam being vented to the atmosphere carrying with it odorous gases. The expenditures on the heat accumulators significantly increased their capacity to prevent any steam from reaching the atmosphere. The result is to produce approximately 1,000,000 gallons per day more hot water than the plant can use. This had to be drained to the sewer. This situation substantiates the point previously made that eliminating one kind of pollution sometimes produces another undesirable type of environmental impact. Non-condensable gases continue to be vented to the atmosphere, however, until facilities were completed in early 1975 to route them to the lime kiln for incineration.

Varkus Scrubber

To bring the recovery boiler stacks into conformity with regulations, Varkus scrubbers are added after the precipitators. By routing the

dust-laden gases at a high velocity through the scrubber chamber where it is blasted with a strong jet of scrubbing liquid, sufficient additional particulates are removed to meet the standard. The impact of the gases and washing liquid creates a fine mist which entraps and, for the most part, dissolves the particles. The liquid is separated from the gases by running the mist through a separator which throws the liquid against the side of the chamber by centrifugal force. The gas vents to the atmosphere while the liquid flows to the dissolving tank or the sewer. Only one Varkus scrubber was in operation at December 31, 1974. Installation of scrubbers on the remaining boilers was completed in early 1975.

Recovery Boiler Modifications

Adding Varkus scrubbers to the recovery boiler system has little effect upon the sulfurous gases emitted to the atmosphere. Significant modifications to the recovery boilers themselves were necessary to attack this problem. By substantially increasing the secondary air supply in the boilers, the TRS gases are incinerated, thereby preventing, for the most part, their reaching the atmosphere.

TRS Monitoring Instrumentation

Each recovery boiler stack has a TRS gas monitoring system that is supposed to measure and record the concentration of TRS gases from the stacks on a continuous basis. According to the plant's environmental engineer, these devices are not operating successfully and must be considered to be in the testing stage. Previous comments indicated a lack of tried and tested monitoring devices for recording the quantity of pollutants flowing from particular sources in a plant.

Foam Breaker

The pulp washing process creates a foam which is air bubbles entrapped in the black liquor. This foam flows to the foam tanks where high speed paddles beat the foam against the side of the tanks, freeing the air which vents to the atmosphere close to the ground while the black liquor flows back into the system.

With the existing foam breaker capacity not enough foam was being removed, with the result that the agitation in the aerated lagoons produced foam which caused a disposal problem. Adding the additional foam breaker capacity substantially reduced the foaming problem at the lagoon.

Phase III In-Plant Changes

This series of in-plant changes involved the addition of 3 sumps and 2 collection tanks at the plant. The function of the system is to collect spills and dumps at strategic locations throughout the mill and pump it all to the number 1 collection tank. From here it is metered to the dilution line on the blow bank where it is used to dilute the pulp prior to washing. Although relatively small amounts of effluent still drains to the sewer system from the primary sources that now drain to the sumps, the new system has significantly reduced the load on the water treatment facilities.

Revised Pollution Estimates

This part of the chapter will be devoted to making any necessary revisions in the quantitative estimates of pollutants produced by the plant. These adjustments may be necessary in light of the in-plant changes made and/or the pollution abatement facilities acquired during the 5-year period ended December 31, 1974.

Revised Air Pollution Estimates

Table 8 below shows the pounds of various pollutants per air dried ton of kraft linerboard pulp produced. The estimates are for the period January 1, 1970, through December 31, 1974.

Table 8

REVISED ESTIMATED POUNDS OF EMISSIONS PER AIR DRIED TON OF KRAFT LINERBOARD PULP PRODUCED

Time Period	H_2S	MeSH MeSMe MeSSMe	SO_2	Particulates
1/1/70 to 6/30/70	11.82	5.88	3.50	18.10
6/30/70 to 9/30/71	11.68	5.78	3.50	16.20
9/30/71 to 12/31/74	11.54	5.68	3.50	14.30

Source: Adapted from Hendrickson, E. R., J. E. Roberson, and J. B. Koogler, Control of Atmospheric Emissions in the Wood Pulping Industry, Volume I (Gainesville, Florida: Environmental Engineering Inc., and Greenville, S. C.: J. E. Sirrine Company, March, 1970), 3-14 and 3-15.

The beginning quantities were taken from Table 1 on page 92. These quantities are assumed to remain unchanged until the addition of the Venturi scrubber on the number 3 lime kiln that serves the linerboard productive process. After adjustments are made for this acquisition the revised estimates are assumed to remain in effect until the addition of the Venturi scrubber on the number 2 lime kiln in September of 1971. This line kiln also serves the linerboard process.

These 2 scrubbers carry efficiency ratings of 99+ percent and replaced 2 mechanical scrubbers with efficiency ratings of approximately 80 percent. Hendrickson's[9] flow diagram 3 portrays a mill with the same

productive facilities as the plant studied. The only differences are a number of air pollution abatement facilities that were not implemented at the plant studied until early 1975, in time for the pollution control agency deadline of June 30, 1975. This configuration does, however, have scrubbers of 99 percent efficiency ratings on its lime kilns. The emissions, per air dried ton of pulp, from this source are as follows:

Hydrogen sulfide	0.20 pounds
Total reduced sulfur compounds	0.30 pounds
Particulates	0.50 pounds

These quantities compare with 0.48, 0.50, and 4.30 pounds respectively, from this source with the 80 percent efficiency scrubbers as noted in Table 1. This represents reductions in these pollutants, per air dried ton of pulp produced of:

Hydrogen sulfide	0.28 pounds
Total reduced sulfur compounds	0.20 pounds
Particulates	3.80 pounds

These amounts were used to reduce the emissions from Table 1 to arrive at the revised estimated emissions in Table 8 for the period 9/30/71 to 12/31/74. Since the number 3 lime kiln also serves the linerboard system it was assumed that this one Venturi scrubber would effect reductions of one-half of those brought about by having Venturi scrubbers on both lime kilns. Consequently, one-half of the reductions listed above were used to arrive at the revised estimates for the period 6/30/70 to 9/30/71 shown in Table 8.

The estimates for hydrogen sulfide and the total reduced sulfur compound gases may be slightly biased. This is because the plant in Hendrickson's diagram vented the non-condensable gases from the digester

and the turpentine condenser to the lime kiln for incineration. This abatement method was not started at the plant studied until early 1975. The possible understatement of these pollutants from this source is believed to be insignificant and is, therefore, ignored for current estimating purposes.

Since none of the abatement facilities acquired during the five-year period ended December 31, 1974, affected the top liner and paper making processes, it is not necessary to revise the estimated quantities of air emissions as shown in Table 2 on page 93. The Venturi scrubber on the number 1 lime kiln that serves this system was modified to bring its efficiency back up to the 99+ percent rating. However, this was not completed until December, 1974. Therefore, the modifications had no effect upon pollution quantities for the 5-year period.

No adjustments are necessary to the estimated pollutants from the power plant boilers as shown in Table 3 on page 94. This is because none of the changes or abatement facility acquisitions during the five-year period affected this area of operations.

Revised Water Pollution Estimates

Table 9 on page 117 presents the estimated total suspended solids and BOD loads of the plant for the five-year period ended December 31, 1974. These indicators form the standards to which the mill must comply. Beginning on January 1, 1973, the plant was limited to 13,000 pounds of suspended solids per day and 10,000 pounds BOD per day. These are averages which can only be exceeded 10 percent of the time. Continued excesses require the submission of a plan of action to bring the plant into conformity with the standards.

Table 9

ESTIMATED WATER POLLUTION QUANTITIES FROM
KRAFT PULP AND PAPER PLANT

Time Period	Total Suspended Solids 1,000 lbs/day	BOD 1,000 lbs/day
1/1/70 to 10/1/72	385.0	120.4
10/1/72 to 9/1/74	23.2	8.8
9/1/74 to 12/31/74	12.1	5.1

For the period January 1, 1970, to October 1, 1972, the estimated impact of the plant's effluent was taken from the engineering study used to design the water pollution abatement facilities. The BOD load is the same as that shown in Table 5 on page 97. For the period October 1, 1972, to September 1, 1974, the estimates were developed from monthly Waste Treatment Plant Performance Reports prepared by the mill's Environmental Engineering Department. Meaningful reports were only available from October 1, 1973, according to the plant environmental engineer. Therefore, the averages for the period October 1, 1973, to September 1, 1974, were assumed to be representative of the plant's performance since the waste treatment facility went into operation in October of 1972. For the period September 1, 1974, to December 31, 1974, the average per the monthly reports is used as the estimate. The significant reduction is primarily attributable to the completion of the phase 3 in-plant changes previously discussed.

The average pH factors shown in Table 4 on page 96 show a wide range from the various sources. The range allowed by the environmental control agency is 6.0 to 9.0. The agency also allowed a temperature maximum of 93° F. for cooling water flowing to the river. For the 15

months ended December 31, 1974, the average water temperature was 86.2° F with a high of 91.6° F and a low of 76° F. Also, for the same period the average pH factor was 7.6 with a range of 8.6 to 7.3. This data was taken from the monthly Waste Treatment Plant Performance Reports. According to the plant environmental engineer, the mill has never been a problem to the river in these areas and with recent changes and facility acquisitions, is not likely to according to existing or projected restrictions.

As expected, the substantial investment by the firm in pollution abatement facilities and in-plant changes has produced significant reductions in the plant's negative impact upon its environment. This is most obvious, of course, in the area of water pollution where a major program was substantially completed in 1972. The effects of the air pollution program will not become so strikingly evident until 1975 when this major program is completed.

Summary

Three major objectives of the research project were completed in Chapter 4.

First, the significant pollution points of the plant were identified and estimated quantities of pollutants flowing from the specific sources were presented. In the absence of reliable and continuous monitoring devices, studies of plants with the same productive configuration as the one studied had to be used to provide the estimates.

The second objective was to identify and briefly explain any pollution abatemen facilities on hand at December 31, 1969. Most of the equipment listed on Table 6 on page 100 did not meet the test of social

investment. This was because their acquisition had been governed by economic considerations with environmental protection as an auxiliary benefit from the expenditure. A condensed diagramatic presentation was made in Figure 7 on page 99 which flow charted the total productive process with the location of pollution points and abatement facilities demonstrated.

The third objective of this chapter of the research project was to identify and briefly explain pollution abatement facilities acquired and in-plant changes made during the 5 years ended December 31, 1974. These were listed in Table 7 on page 104. Revised flow diagrams emphasizing the acquisitions and changes were presented in Figures 8, 9, and 10 on pages 106, 107, and 108, respectively. Finally, adjusted pollution load estimates were given in Table 8 on page 114 and Table 9 on page 117. As expected, the substantial expenditures made by the firm to reduce the plant's negative environmental impact produced significant reductions in certain pollution areas. Most noticeable were the steep declines in water pollution indicators resulting from the completion of the majority of the water pollution program in 1972 and the remaining part in 1974. Aggregate expenditures under this program totaled approximately $7 million. Equally evident reductions in air pollutants should be attained when the air pollution program is completed in 1975.

As indicated earlier, firms should effectively communicate efforts and accomplishments in this area of their social responsibilities. Developing such a supplemental communication device to assist business in this respect is the broad overall objective of this research project. Demonstrating the format and content of such a supplemental report will be accomplished in Chapter 5 to follow.

NOTES

1. Hendrickson et al., op. cit., 9-1.

2. Ibid., 3-17a.

3. Ibid., 3-33a.

4. Ibid., 4-60.

5. McGauhey, op. cit., 11.

6. Nemerow, Nelson L., Liquid Waste of Industry (Reading, Mass.: Addison-Wesley Publishing Company, 1971), 4.

7. U. S. Department of the Interior, op. cit., Table A-4.

8. In order not to specifically identify the plant studied, the engineering consulting firm, nor the report name will be given.

9. Hendrickson et al., op. cit., 3-25a.

CHAPTER V

THE EXPANDED ACCOUNTING REPORTING MODEL

A Need Reasserted

Effective critics of many aspects of business operations have, in recent years, produced a changed cultural environment in which business must attempt to function. Increased legislative constraints have been enacted restricting the freedom of choice of business executives in decisions affecting relationships with customers, employees, competitors, communities, the environment, etc., etc. Each additional restriction brings increased public accountability for the areas of entity activities affected. Furthermore, every sphere of continuing criticism of business operations carries a potential for still more legal constraints and public accountability. Gaskell cites the environment and corporate public accountability as two of the four "major categories of issues of prime concern to corporations attempting to conduct their business within the existing framework of society . . . The principal effect of increased emphasis upon corporate accountability has been to apply to corporations mounting pressures for continuous and organized responses."[1] (my emphasis)

Existing stockholders' reports, which purport to communicate the entity's efforts and accomplishments for a period of time, contain references to social goals, commitments, and achievements in the letters from the president and/or chairman of the board or in narrative statements

somewhere in the report. The formalized, traditional accounting reporting model, exemplified in the financial statements and notes which are supported by an independent auditor's opinion, are limited to reporting the results of economic events recorded, on a historical cost basis. The stockholders' report, as presently constructed, does not meet the need for "organized and continuous response" in the areas of social activities of business entities. This deficiency in communications is the problem to which this research project has been directed.

The proposition is herein made that information portraying the recognition of social responsibilities of the firm, and the efforts that have been exerted, and are planned, to deal with these responsibilities and the accomplishments to date should be formally structured in a supplemental reporting device to be included in the annual stockholders' report as an adjunct to the traditional accounting financial statements. At present, this supplemental reporting model will be limited to the area of the environmental effects of the firm's operations. This reporting device, to be called the Environmental Impact Report, will briefly narrate the entity's pollution problems and efforts that have been and will be expended to deal with these problems. In addition, expenditures for the acquisition and operation of pollution abatement facilities for the most recent 5-year period will be presented. Also to be shown in the Report will be actual or estimated quantities of pollutants that have been produced by the entity's productive facilities over the same 5-year period. It will also be disclosed as to whether the firm's facilities are in compliance with existing pollution standards dictated by law. It is further proposed that the existing accounting reporting model be expanded to show separately the cost of pollution abatement facilities as social investments in

the statement of financial position and the depreciation and operating costs of these facilities as social costs in the income statement. It is believed that this expanded accounting reporting model encompassing the supplemental Environmental Impact Report will assist firms in meeting the needs for "continuous and organized" communication of efforts and accomplishments in this important area of social activities of the firm.

It is conceivable that this supplemental report could be expanded in the future to include indicators of performance in other areas of social responsibilities of business entities. If this occurs, the name of the report would have to be changed to reflect the increased area of reporting responsibilities. The possibility also exists that assertions presented in the supplemental report may also be audited by some independent firm or group and an opinion issued according to standards to be developed. Both of the potentialities are discussed more thoroughly in the last section of this chapter dealing with additional areas of research.

The endeavors underlying this dissertation to this point have encompassed a case study of a large, integrated pulp and paper plant. One goal of the study is to accumulate data to be included in the Environmental Impact Report and the expanded accounting financial statements. The broad, overall objective of the research effort is to demonstrate the methodology for developing information to be included in the proposed expanded accounting reporting model. The completion of this data accumulation function will be the first area of concern in this chapter.

Operating expenses related to the pollution abatement facilities acquired by the plant will be developed. This will be done for the 5-year period ended December 31, 1974, in order that they may be presented in the Environmental Impact Report. Figures for the last two years will

also be shown in the expanded income statement of the firm. The next efforts concerning data accumulation will be directed at gathering statistical information necessary for the computation of the estimated environmental impact of the plant's operations for the same 5-year period. Finally, a table of air emission standards under which the mill must operate will be presented along with statements whether the plant is in conformity with these standards.

The next objective of this chapter is to present an illustrated expanded accounting reporting model comprising the Environmental Impact Report and the statement of financial position and income statement displaying as separate items the social investments and social operating costs. This extended communication device offers business an effective instrument for providing continuous and organized response to interested parties concerning its efforts to meet its social responsibilities in the area of protecting the environment.

The last section of the chapter will be devoted to identifying areas where additional research may be directed to expand and improve social responsibility accounting of business entities.

Operating Expenses

It is almost axiomatic that the purchase of substantial quantities of pollution abatement facilities will result in increases in operating expenses to keep the equipment working as required.

Table 10 on page 125 presents the depreciation and operating expenses incurred for the pollution abatement facilities in operation at the plant studied. The starting point for the quantities shown in Table 10 was the Survey on Pollution Abatement Costs and Expenditures filed annually with

Table 10

SOCIAL OPERATING EXPENSES RELATED TO POLLUTATION ABATEMENT FACILITIES

Year	Depreciation	Other Operating Expenses	Total
1970	$ 5,350	$ 1,294,487	$ 1,299,837
1971	25,117	2,853,452	2,878,569
1972	140,141	962,413	1,102,554
1973	395,827	1,683,491	2,079,318
1974	449,129	2,874,871	3,324,000
	$ 1,015,564	$ 9,668,714	$ 10,684,278

the Social and Economic Statistics Administration of the U.S. Department of Commerce by the plant. Depreciation expenses shown in these annual surveys were based primarily upon the items shown in Tables 6 and 7 on pages 100 and 104, respectively. In addition, depreciation and operating expenses on the Imhoff Tank system (sanitary sewer system) not shown in the tables was included. The figures in the Survey were adjusted by eliminating depreciation expense for those items listed as capital investments in Tables 6 and 7 and for the Imhoff Tank system. Adjustments were also made for operating expenses associated with the plant's sanitary sewer system.

The other operating expenses are primarily labor, repairs and maintenance, purchased power, expense JOPA's primarily associated with the air and water pollution programs and low sulfur fuel oil premium. In 1971, approximately $2.4 million represented the excess cost of the one percent fuel oil used over the cost of the fuel oil that would have been

burned in the absence of pollution controls. Placing the water treatment facilities in operation in late 1972 accounts for the significant increase in operating costs in 1973 and 1974. Purchased electricity quantities and rates also substantially increased during this period.

Discussions with plant personnel indicate that the water treatment expenses are separate department classifications. Air pollution operating expenses, however, are allocations based upon the percentage of gross asset values to total assets within each department. Due to the differences in classification of some assets in this research project, the result is to overstate operating expenses for social purposes. No adjustment will be made for this possible overstatement as it is believed to be relatively insignificant due primarily to the fact that the substantial majority of capital expenditures listed are classified as social costs and this amount itself represents only a relatively small percent of the total fixed assets of the various operating departments.

Additional Statistical Data

This section of the chapter will present additional statistical data necessary for computing the total environmental impact of the plant. Information displayed here will generally be combined with data from the tables in Chapter 4 to arrive at quantitative annual estimates of the various pollutants flowing from the productive processes to be shown in the Environmental Impact Report.

Finished Product Output

Table 11 on page 127 lists the tons of finished products produced by the mill over the 5-year period ended December 31, 1974. The tons of paper and top liner shown in Table 11 will be combined with the estimated

Table 11

FINISHED PRODUCT OUTPUT
(Air Dried Tons)

Year	Paper and Top Liner	Linerboard
1970	98,364	313,543
1971	86,718	337,899
1972	79,622	384,836
1973	88,859	377,329
1974	91,508	362,547

pounds of emissions per ton of product shown in Table 2 on page 93 to arrive at the total estimated pollutants from this activity. The same computations for linerboard will be made using the outputs shown in Table 11 and the estimated pollutants shown in Table 8 on page 114. It will be noted in Table 8 that the estimated emission quantities changed as abatement facilities were being added during the 5-year period. The assumption will be made that production takes place evenly throughout the year and fractional adjustments required for the different periods shown in Table 8 will produce satisfactory estimates for our purposes. It is believed that the differences that might result from developing actual output for these fractional year periods would be relatively insignificant in relation to the total annual estimated impact.

Estimated Fuel Consumption

In order to gauge the environmental effect of the fuel consumed in the power boilers it is necessary to ascertain the pounds of fuel oil and bark used over the 5-year period.

Annual operating reports showing the total gallons of fuel oil consumed were used to develop the quantities of fuel oil consumed shown in Table 12 below. Each gallon of fuel oil weighs approximately 8 pounds. Another annual report indicates the number of cords of wood used during the year. Each cord of wood produces approximately 700 pounds of bark used in the combination boilers. Multiplying the number of cords used times 700 pounds per cord produced the estimated pounds of bark in Table 12. The quantities of bark shown may be slightly more or less than the actual quantity burned due to variations in bark inventory at year end. Discussions with plant personnel indicate that the quantity of bark on hand is generally small and any variation in inventories would be relatively insignificant. Consequently, no adjustment for these slight variations is considered practical or necessary.

Table 12

POUNDS OF FUEL BURNED
(Thousands of Pounds)

Year	Fuel Oil	Bark
1970	338,491	442,151
1971	352,956	461,838
1972	314,166	508,687
1973	310,697	516,422
1974	294,684	508,126

Pollution Standards

The plant studied operates under the rules of the Florida Department of Pollution Control. The local municipality in which the plant is located also has a pollution control agency and standards, some of which are stricter than the federal or state standards.

Table 13 on page 130 presents the location of the 14 stacks at the plant that are subject to pollution controls. The standards to which the stacks must comply, as well as indications as to whether they are in compliance at December 31, 1974, are also given in the table.

The process weight table rates for the dissolving tanks and lime kilns relate to the pounds per hour of particulate emissions permitted according to the pounds per hour of material processed (smelt and sludge respectively). Both facilities process approximately 20,000 pounds per hour of material which requires that a standard of 14.99 pounds of particulates per hour be maintained. A series of 3 tests is made on each stack every 6 months with the results forwarded to the Department of Pollution Control. Discussions with the plant's environmental engineer indicate that the mill has no difficulty in meeting these standards.

The bark combination boilers meet the required standards when bark is being burned as the exhaust stream is routed through the scrubbers. The problem is that the plant does not produce enough bark to be burned all the time which results in fuel oil only being burned in these boilers at certain intervals. The scrubbers cannot be operated when only fuel oil is burned. This is because the scrubbers would deteriorate rapidly, substantially shortening their useful lives.

Substantial quantities of air pollution abatement facilities had been acquired or was in the process of being acquired under the plant's

Table 13

AIR POLLUTION STANDARDS IN EFFECT
FOR KRAFT PULP AND PAPER PLANT
AT DECEMBER 31, 1974

Stack Location	No. Stacks	Standard	In Compliance?
Dissolving Tanks	3	Process Weight Table Rate	Yes
Lime Kilns	3	" " " "	Yes
Power Boilers	3	0.1 pound particulates per million BTU of heat input	No
Bark Boilers	2	0.3 pound particulates per million BTU of heat input when burning bark	Yes
Bark Boilers	2	0.1 pound particulates per million BTU of heat input when burning fuel oil only	No
Recovery Boiler	3	3.0 pounds particulates per 3,000 pounds black liquor solids burned	No
		17.5 parts per million TRS gases	No

$8 million air improvement program previously discussed. This fact will be revealed in the supplemental Environmental Impact Report.

As indicated in Chapter 4, the plant was subject to water pollution standards at December 31, 1974 of 13,000 pounds of suspended solids and 10,000 pounds of BOD per day. After implementing the phase 3 in-plant changes late in 1974 the plant was in compliance with the standards.

Illustrating the Expanded Accounting Reporting Model

This section presents the end product of this research project, the expanded accounting reporting model. The Environmental Impact Report is the proposed supplemental statement to be included in the firm's annual

report to outsiders. The traditional Statement of Financial Position and Income Statements will be demonstrated with social investments and operating expenses shown separately. The only actual figures included in these statements will be the social investments presented in Tables 6 and 7 in Chapter 4 and the operating expenses shown in Table 10 on page 125. All other figures in the statements will be fictitious in keeping with the firm's constraint that actual financial data, other than pollution facility acquisition and operating costs, not be divulged. As indicated in Chapter 2, the development of a set of financial statements complete with notes, auditor's opinion, etc., is not necessary for the purposes of this research project.

Exhibit 1

ENVIRONMENTAL IMPACT REPORT

The Company, by the nature of its manufacturing processes, can impose a substantial negative force upon the environment. In an effort to minimize this undesirable effect from our operations, the firm has committed itself to the development and implementation of significant air and water pollution abatement programs. In late 1972 water pollution abatement facilities were completed at a cost of approximately $6.2 million. An additional $529 thousand was expended under the program in 1974. Also in 1974, an air pollution control program was implemented which is expected to cost approximately $8 million by the time it is completed in mid-1975.

The magnitude of the social expenditures made by the Company over the last 5 years, as shown in the schedules below, in addition to the approximately $6 million still to be invested under the air pollution abatement program, indicate the Company's commitment to meeting its social responsibilities in the area of protecting our environment. The substantial improvements in our water pollution flows, as shown in the schedule below, portrays the accomplishments these efforts have attained. It is expected that equally significant improvements in reducing the firm's air pollution flow will occur as the air pollution abatement facilities become operational in early 1975.

Exhibit 1 (Cont.)

SOCIAL INVESTMENTS IN POLLUTION ABATEMENT FACILITIES
FIVE YEARS ENDED DECEMBER 31, 1974

Year	Control Facilities		Total
	Air Pollution	Water Pollution	
1970	$ 119,508		$ 119,508
1971	278,171	$ 367,982	646,153
1972		5,790,115	5,790,115
1973	269,310		269,310
1974	1,810,985	528,603	2,339,588
Totals	$ 2,477,974	$ 6,686,700	$ 9,164,674

SOCIAL OPERATING EXPENSES RELATED TO
POLLUTION ABATEMENT FACILITIES
FIVE YEARS ENDED DECEMBER 31, 1974

Year	Depreciation	Other Operating Expenses	Total
1970	$ 5,350	$ 1,294,487	$ 1,299,837
1971	25,117	2,853,452	2,878,569
1972	140,141	962,413	1,102,554
1973	395,827	1,683,491	2,079,318
1974	449,129	2,874,871	3,324,000
Totals	$ 1,015,564	$ 9,668,714	$10,684,278

Exhibit 1 (Cont.)

ESTIMATED AIR EMISSIONS FROM PLANT OPERATIONS
FIVE YEARS ENDED DECEMBER 31, 1974

Year	Total Tons	Pounds Per Ton of Finished Product
1970	12,023	58.4
1971	12,086	56.9
1972	12,909	55.6
1973	13,052	56.0
1974	12,778	56.3

ESTIMATED WATER POLLUTANTS FROM PLANT OPERATIONS
FIVE YEARS ENDED DECEMBER 31, 1974
(Thousands of Pounds)

Year	Total Suspended Solids	BOD
1970	134,750	42,140
1971	134,750	42,140
1972	101,710	31,941
1973	8,120	3,080
1974	6,822	2,647

SOLID WASTES

The plant has experienced no solid wastes disposal problems in the past nor is it expected to in the immediate future. Solid waste materials produced by operations have been, and will continue to be, used as land fill at the plant site. Alternatives are being considered for solid wastes control when plant site utilization is no longer possible.

Exhibit 1 (Cont.)

COMPLIANCE WITH ENVIRONMENTAL STANDARDS

At December 31, 1974 the plant was in compliance with water pollution standards in existence at that time. The bark combination stacks are in compliance with air emission standards when bark and fuel oil are being burned in the boilers. These stacks are not in compliance with regulations when only fuel oil is being burned. None of the remaining stacks at the plant were in compliance with air emission standards at December 31, 1974. It is expected that all stacks at the plant will conform to environmental standards by the June 30, 1975 deadline imposed by the Florida Department of Pollution Control.

Exhibit 2

FLORIDA PULP AND PAPER COMPANY
INCOME STATEMENT
YEARS ENDED DECEMBER 31, 1973 AND 1974
(000 omitted)

	1974	1973
Sales	$ 114,368	$ 91,187
Less: Cost of goods sold	88,771	72,038
Gross Profit on Sales	25,597	19,149
Expenses:		
Selling and administrative	13,310	12,720
Depreciation-operating facilities	673	594
Depreciation-pollution abatement facilities	449	396
Social operating expenses	1,683	2,875
Interest on social investments	900	630
Total	17,015	15,215
Earnings before income taxes	8,582	3,934
Provision for income taxes	4,291	1,967
Net earnings	$ 4,291	$ 1,967
Earnings per share	$ 4.29	$ 1.97

Exhibit 3

FLORIDA PULP AND PAPER COMPANY
STATEMENT OF FINANCIAL POSITION
DECEMBER 31, 1973 AND 1974
(000 omitted)

	1974	1973
ASSETS		
Current assets	$ 30,584	$ 24,896
Property, plant and equipment, at cost:		
Land, buildings and equipment	61,645	57,721
Less accumulated depreciation	50,424	47,821
Land, buildings and equipment, net	11,217	9,900
Pollution abatement facilities, at cost	9,290	6,964
Less accumulated depreciation	1,472	1,023
Pollution abatement facilities, net	7,818	5,941
Other assets:		
Advanced payments under timber-purchases contracts	2,735	2,472
Total assets	$ 52,354	$ 43,209
EQUITIES		
Current liabilities	$ 14,571	$ 10,717
Long-term debt-social investments	10,000	7,000
Total liabilities	24,571	17,717
Stockholders' equity:		
Common stock, authorized 4,000,000 shares of $1 par value, issued and outstanding, 1,000,000 shares	1,000	1,000
Paid-in capital in excess of par	19,000	19,000
Total paid-in capital	20,000	20,000
Retained earnings	7,783	5,492
Total stockholders' equity	27,783	25,492
Total equities	$ 52,354	$ 43,209

Contributions of the Research Project

Some contributory implications of the expanded communication device proposed in this dissertation were reasserted at the beginning of this chapter. The primary immediate benefit is to meet the need for effectively conveying the business community's recognition of, and efforts to forcefully respond to, social responsibilities in the important area of protecting the environment. Another significant benefit that will flow from the accumulation of information to be included in the expanded reporting model will be to assist in enabling businessmen to make positive presentations at public hearings concerning their activities in specific social areas. Bradshaw observes that "All too often businessmen appear at pollution hearings in a totally defensive posture . . . They should appear at the hearing and provide constructive plans for action explaining what is technically feasible, what it will cost, and what the result would be in the water or the air. It is just a matter of taking a constructive approach instead of the defensive."[2]

Churchill makes the point that "The exact future of the corporation's social responsibility is open to question; that it will be held more responsible by law, by pressure, or by choice is beyond doubt."[3] Immediate concerns with recessions, unemployment, inflation, and other economic problems may momentarily delay the implementation of increased social responsibilities of business. In the long run, however, pressures will continue for increasing public accountability in certain areas of social activities of business. The experience gained from providing socially relevant information for the proposed expanded accounting reporting model should assist businessmen in developing new information for

additional areas of social activities that come under closer societal scrutiny. I cannot help but agree with Bradshaw when he states that "Either the businessman will lead in the arena of social change or somebody else will. The businessman who stays out of the arena will have no one to blame but himself if the solutions offered are not workable."[4] It is felt that the methodology demonstrated in this research project and the illustrated expanded accounting reporting model herein developed will contribute to businessmen's exercise of their traditional role of leadership in effecting change.

The last remaining significant task of this research project is to summarize those procedures developed herein that could be utilized by any business entity that wished to accumulate information to be included in the expanded accounting reporting model. It is the development and presentation of these procedures and their general applicability that constitute one of the major contributions of this research project.

The listing and discussion of the procedures presented below will omit or simplify a number of time consuming operations that were necessary for the completion of this particular research project. One of these omitted procedures would be the general description of the operating facility. Another omission or simplification would be the descriptions presented of the pollution abatement facilities in existence at the beginning of the reporting period, as well as those acquired during the reporting period. The reason the exclusions or condensations are possible is that it is a logical expectation that the firm would assign a qualified employee the responsibility of gathering the desired supplemental information. This individual would be expected to have a general understanding of the firm's productive processes, environmental impacts,

and pollution abatement facilities. This would be in sharp contrast to this researcher's almost complete lack of knowledge of the operations of the entity studied as this project began.

Attention will now be directed to enumerating the procedures necessary to accumulate the information to be included in the expanded accounting reporting model.

Specify the Reporting Period

From a practical standpoint one of the first decisions to be made after it has been deemed desirable to expand the reporting model is to establish the time period for which the information is to be presented. This establishes the limits of most of the information gathering activities. The longer the reporting period, the more difficult it will be to develop the desired information for the earlier years. Five years was the time period used in the research project. A longer period would have revealed little activity in terms of expenditures for acquisition of pollution abatement facilities as imposed standards are a fairly recent phenomenon for most businesses.

Identify Pollution Sources of Entity

Assuming that the individual assigned the responsibility of accumulating the desired information was from the accounting department of the entity he would call upon members of the engineering staff or operating personnel familiar with the productive processes to assist in identifying the significant pollution points of the facility. This would be done as of the beginning of the reporting period in order that existing and acquired abatement facilities could be related to the particular area of productive activity.

Develop Quantitative Estimates of Pollutants

These same individuals would also be very helpful in developing quantitative estimates of pollutants produced by the various areas of productive activity over the reporting period. This task may prove difficult, particularly during the early years of the reporting period. Reliance may have to be placed upon empirical studies of entities with similar productive facilities. On the other hand, if the entity has been making tests and reports for internal or control agency purposes, these may prove helpful in the completion of the procedure. Consulting engineering studies of the productive facility offer another source of estimates of pollutants produced by the firm's activities. Ideally, continuous monitoring devices or tests at pollution sources over the entire reporting period would provide the most complete and reliable estimates. This source of estimates of environmental impacts from operations may prove to be scarce in actual practice for firms in most industries. These measures are generally expressed in pounds or tons of some pollutant such as particulates, gases, or BOD (biochemical oxygen demand upon receiving waters). Other measures peculiar to a particular industry may also be utilized.

Accumulate Additional Statistical Data

Additional statistical data may be necessary before the entity's environmental impact can be estimated. Examples would be total annual output in units of product in order that physical impact per unit of product may be computed, if practical. If the entity produces its own power, then quantities of fuel consumed (barrels of fuel oil or tons of coal) would have to be extracted from operating reports, if available. If not, a review of purchase invoices may be necessary. The quality of

the fuel consumed from the standpoint of sulfur content is of great importance in estimating pollutants from this source. If the entity were subject to varying sulfur content restrictions over the reporting period, then notation of the quantities allowed and periods concerned is important for estimating purposes.

Ascertain Pollution Standards Applicable to Entity

The firm's environmental engineer or other responsible operating personnel would also generally be the best source for determining the pollution standards, if any, to which the entity must comply. A number of factors important to the supplemental Environmental Impact Report are determined at this point of the information accumulation process. One is the determination as to whether the entity is in compliance with pollution standards imposed by law. If not, does the firm expect to be in compliance by the deadline date imposed by the controlling agency? If compliance is not expected by the imposed deadline date, what are the consequences in terms of shutdown or penalties?

Determine the Pollution Abatement Facilities in Operation at the Beginning of Reporting Period

It is necessary to determine if any pollution abatement facilities were in existence as of the beginning of the reporting period and their known or estimated operating efficiencies. One reason for this is to assist in identifying the acquisition and operating costs of the facility in order that they may be properly reclassified to reflect the social character of the expenditures. Discussions with the environmental engineer or responsible operating personnel should also indicate if any economic benefits such as raw material recovery occurs as a result of the operation of the abatement facility. In this event, the value of

the economic benefits would have to be estimated in order that the acquisition and operating costs of the facility could be allocated into its economic and social classifications. The operating efficiencies of the pollution abatement facilities may be important in estimating the pollution effects of the particular area of operations.

Enumerate the Pollution Abatement Facilities Acquired During Reporting Period

The determination of the pollution abatement facilities acquired (or in-plant changes made) during the reporting period is important for two reasons. First of all, these facilities or changes can be quite expensive and the expenditures for their acquisition and operation need to be properly classified as social expenditures for accounting record purposes and for proper presentation in the Environmental Impact Report. The allocation of cost problem occurs when economic benefits result from the acquisition and operation of these facilities. The second important reason for identifying the abatement facilities acquired is that their utilization reduces the negative environmental impact of the entity's operations. Accordingly, it is necessary to ascertain the dates these facilities became operational and their efficiency ratings and effects upon pollution flows in order that adjustments can be made in the estimates of pollutants produced by the entity's productive activities.

List the Pollution Abatement Facilities in Process of Being Installed, Budgeted, and Planned

Discussions with the environmental engineer or operating personnel of the entity plus a review of capital expenditure work orders, approved and projected capital expenditure budgets will enable the person responsible for supplemental information accumulation to ascertain planned

abatement facility acquisitions. The budgeted acquisition cost of these facilities can generally be readily determined. This is necessary for reporting in the Environmental Impact Report. It is also usually important to indicate when these facilities are expected to become operational and the projected benefit from their operation (to bring the facility into compliance with standards by deadline dates).

Examine Property Records to Determine Acquisition Cost and Accumulated Depreciation on Pollution Abatement Facilities Acquired

Armed with a listing of pollution abatement facilities in existence as of the beginning of the reporting period and those acquired during the reporting period, the individual can begin to accumulate the total social investment of the entity by searching the property records. The difficulty of the task will be determined by the amount of information available from the accounting property records. If pollution abatement facility acquisitions have been fairly well detailed, then the job may not prove to be too difficult. On the other hand, if the pollution abatement facility is but a part of a larger fixed asset acquisition, it may be necessary to resort to correspondence with manufacturers or contractors in an effort to ascertain the cost of the facility. A schedule of acquisition cost and depreciation expense on the facilities by years of the reporting period is necessary for inclusion in the Environmental Impact Report. The cumulative social cost and related accumulated depreciation for the two latest years will be shown as separate items in the statement of financial position of the entity after reclassification from the regular fixed asset accounts.

During this phase of the information accumulation process it would seem to be worthwhile to set up accounting procedures that would classify

future expenditures for pollution abatement facility acquisitions as social investments and the related depreciation on these facilities as social depreciation to be reported separately in the entity's income statement.

Review Accounting Records to Identify Cost of Operating Pollution Abatement Facilities for Reclassification to Social Expenses

Substantial investments in pollution abatement facilities almost always result in additional recurring operating expenses in addition to the social depreciation on the facilities identified above. If the abatement facility acquisition is a substantial one such as a complete water treatment facility, then new expense classifications would most assuredly be developed for some or all aspects of its operations. In any event, this part of the information gathering activities will require an analysis of the accounting records to determine expenses that are related to the abatement facilities. This should not be attempted, however, until a study has been made to identify the employees involved in operating these facilities, the supplies required, and the fixed assets provided for their activities in addition to the abatement facilities themselves (trucks and other equipment, offices, storage space, etc.). For most large entities separate environmental engineering departments have been established to deal with representatives of the pollution control agencies in addition to overseeing the planning, installation, and operation of the abatement facilities. The cost of operating these departments should, of course, be charged to social operating expenses.

One of the largest expenses associated with many types of pollution abatement facilities is electric power consumption. Meters may be used on large installations such as water treatment facilities that utilize

aerators and large pumps. Engineering estimates will have to be used in many instances where pollution abatement facilities are added on to existing productive equipment. These procedures would be applicable to entities that purchase electric power or those firms that generate their own power.

Another very costly expense that may be encountered by firms that generate their own electric power is the premium paid for low sulfur content fuels. In addition to the electric power costs allocated to social operating expenses determined in the preceding discussion, the premium paid for this more costly fuel, over and above that which would normally be paid, should also be charged to social operating expenses. As previously noted, care should be taken to note the dates applicable and the sulfur content allowed if the standards changed during the reporting period as this affects the amount of the premium.

It is expected that the completion of this phase of the supplemental information accumulation process will result in a number of cost allocations from normal operating to social operating expense classifications. Allocations are nothing new for accountants. It would also be expected that account classifications would also be developed and implemented to facilitate social operating expense accumulations in the accounting records for future reporting purposes.

It is necessary, of course, to develop annual social operating expenses for the term of the reporting period of the Environmental Impact Report. The amounts for the latest two years would also be shown as separate items in the firm's income statement.

Analyze Long-Term Debt for Possible Reclassification Purposes

If the entity has incurred long-term debt to finance acquisition of pollution abatement facilities, then this segment of the firm's liabilities should be reclassified to long-term debt on social investments. The related interest expense applicable to this portion of the long-term debt should be reclassified to a separate interest on social investments account to be shown separately in the income statement. Interest expense on indebtedness for acquisition of pollution abatement facilities should also be determined for the reporting period to be used in the Environmental Impact Report. Procedures for permanent recognition of this type of indebtedness and related interest expenses and the recording in the proper accounts should also be developed and implemented.

It is expected that the efforts necessary to complete these procedures will vary greatly from one entity to another, depending upon the complexity of the production processes, the significance of the impact of these processes upon the physical environment, the completeness of the entity's accounting records, and the qualifications of the individual assigned the responsibility of accumulating the information for the expanded accounting reporting model. Hopefully, the more effective communication device portraying the firm's commitment to reaching social goals desired by society will be well worth the effort.

Areas of Additional Research

Discussed in this final section of the research project are possible areas where additional research might serve to improve the number and quality of information communicated by business entities concerning activities that may indicate recognition of, and attempts to respond to,

social responsibilities. The last area of research suggested concerns improving communication between various agencies of government whose policies, which are aimed at attaining agency objectives, may be operating at cross purposes in terms of what is best for society as a whole.

Measurement Refinement

Previous mention was made of Churchill's four levels of measurement, three of which were utilized in this research project. The fourth, or highest, level of measurement, it will be recalled, required the determination of "foregoing alternatives" and "displaced activites." Churchill continues by stating that "There is no question that such a measurement system (fourth level) would be of tremendous value. There is a question, however, if it can be developed to any extent in the near future. Nonetheless, it is important enough to warrant serious research."[5] While few would disagree with the need for additional work in this area of measuring the social aspect of economic activity, it seems to me that a more pressing research need is at the lower three levels, particularly the input (efforts expended in identified, socially relevant activities) and process (output-tons of particulates captured) levels.

Input measurement refinement encompasses procedures for recognizing social expenditures for pollution abatement facility acquisition and operation. The list of pollution control facilities that was provided by plant personnel included all assets acquired that improved pollution flows even though some had been purchased because of their economic benefits long before pollution standards would have made their acquisition necessary.

It was not considered necessary to attempt to verify assertions by

plant engineers and accountants that specific pollution abatement facilities provided little or no chemical recovery returns or cost savings. Löf, Hearon and Bower state, however, that "Only infrequently would there be no partially offsetting savings or additional cost penalties associated with reducing the discharge of a particular material."[6] Where some chemical recovery or expense reduction occurs from the operation of pollution abatement facilities, measurement procedures need to be developed to recognize this fact and allocate part of the cost of the equipment to capital assets and the remainder to social assets.

At the plant studied, rather crude allocation procedures were utilized to report some abatement facility operating cost to the Department of Commerce. More attention should be directed to recognizing social operating costs. This may be no easy task considering potential savings that may accrue in repairs and maintenance, for example, as corroding pollutants are removed from plant wastes. In addition, estimated lives of other depreciable assets may be extended from these activities. These cost savings could be credited against the social operating or depreciation expenses of the related abatement facilities.

The land-fill operations of the plant studied, which utilized productive wastes, are charged to water pollution operating expenses. If this waste results in raising low-lying, marshy land to the extent that its utility is increased, then consideration should be given to capitalizing these amounts in the land account.

The third, or output, level of measurement is practically nonexistent at the plant studied. In the research project, reliance had to be placed upon studies that had been made of the impact of productive facilities with substantially the same manufacturing configuration as the

plant studied. As monitoring devices become more sophisticated and reliable, the determination of the plants' environmental impact should be more easily ascertainable. Reported quantities of pollutants in the Environmental Impact Report will be more accurate and meaningful in terms of evaluating the entity's performance.

It is important to improve the quality of the quantitative presentations relative to businesses' socially oriented activities. This is necessary to more accurately reflect actual costs of protecting the environment. Paper Profits,[7] a study of pollution in the paper industry by the Council on Economic Priorities, has been praised as "the detailed and highly respected survey of pollution in the paper industry."[8] The writer continues by noting that this type of survey is an "example of what's needed"[9] for all industries according to critics because they present the "plain facts."[10] The plain fact related in this survey indicated that a minimum investment in pollution abatement facilities at the plant studied, other than that already budgeted, was $800,000.[11] The implication being that this amount would bring the plant's air pollution problem to acceptable levels according to the Council's researchers.

The difficulty with relying upon organizations outside the business community for information concerning what it is doing and planning to do in the realm of protecting the environment and other socially desirable conduct is that they may substantially understate the cost of dealing with the trouble. The plant studied will end up spending approximately 10 times the $800,000 in order to bring its air pollution problems under control. Bauer and Fenn state that "Numbers are rightfully both a device whereby an individual brings order to the world in which he must act and a means of communicating his view of the state of affairs to other people."[12]

It seems that a fruitful area of research exists in improving the quality of numbers that may serve as social indicators of business activities.

Developing Expanded Auditing Procedures

The Environmental Impact Report moves assertions concerning expenditures for acquiring and operating pollution abatement facilities from a public relations oriented language of the narrative section of the stockholders' report to a more formalized structure. If this occurs, it would not be surprising to see pressures exerted to add further strength to the amounts shown by having them attested to by outside auditors.

Andrews states that "Some authorities foresee complete 'social audits' of firms by outside consultants within a decade, just as outside accountants conduct financial audits today . . . But before any of this can be done, somebody has to set up some standards and some techniques."[13] Existing social audit efforts according to Andrews are internally performed and "usually . . . involves close scrutiny of a firm's operations, personnel practices, purchasing, investments, and products to see how they affect other people."[14]

Whether the outside consultants that may some day perform social audits of business entities will be primarily accountants or some other group of professionals appears to depend upon whether accountants assume a leadership role in assisting business in developing indicators of social performance.

Attesting to the dollar expenditures for acquisition and operation of pollution abatement facilities appears to be but a relatively minor extension of existing auditing procedures. Determination of chemical recovery capabilities of facilities for possible social/economic cost

allocation may require consultations or confirmations with company or outside engineers. Attesting to quantitative reports of emissions may require use of engineering consultants as part of the audit team. Unannounced sampling of effluents for independent analysis or readings of monitoring equipment may be used to lend credence to internally generated reports. Confirmations with regulatory agencies as to compliance status may be utilized by the auditors.

It appears that research aimed at developing the auditing procedures necessary to attest to the information contained in the Environmental Impact Report could be accomplished relatively easily. If social indicators are expanded to include personnel practices, purchases, investments and products, then not only does the development of the quantitative aspects of these indicators become substantially more difficult, but also so does the determination of auditing procedures and standards.

Accountants may understandably be reluctant to expand their area of responsibility to include an opinion on supplemental social data formalized in the entity's annual report to stockholders. But as their responsibility increases, so does their opportunity to be of additional service to business and society. If accountants fail to expand their capabilities in the area of attesting to socially relevant information contained in stockholders' reports, then chances are some other multi-disciplined group will seize the initiative in this area.

It is conceivable that social audits by some professional group, hopefully with accountants playing a dominant role, could be utilized to replace some of the multitude of audits by various governmental agencies concerned with business operations.

Additional Social Indicators

As noted above, some critics would like to see activities in a number of areas of business operations examined and reports expanded with indicators of some sort revealing the recognition of, and attempts to meet, social responsibilities in these areas.

A number of surrogates which supposedly represent indications of social responsibility in personnel relations have been suggested. Quantitative reports of numbers of women, minorities, underprivileged, etc., that the firm has employed is one. Another is the number of these individuals that have been promoted to positions of responsibility in the firm. Dollar expenditures to increase the employability and/or promotability of certain individuals in the firm or community is another. Possibly included may be employee turnover rates or absentee rates as indicators of employee satisfaction with the firm.

Donations have been listed as an indicator of socially responsible business and should be reported as a social indicator. Dollar expenditures to charitable organizations in the community by the entity can be easily determined from the accounting records. Many firms may be reluctant to donate substantial sums of money to charitable organizations because of their concern with the effectiveness of this type of organization in producing results at the level needed. Furthermore, firms may permit employees and executives to devote considerable time to work in charitable organizations while still receiving full compensation from the company. Should part of these salary costs be allocated to charitable donations and reported accordingly? Even more difficult is the determination of the opportunity cost of potentially lost business that may have been produced by the employee's efforts.

Indications are that if the social responsibility accounting report of business entities is to be expanded significantly, then substantial efforts need to be devoted to developing the quantitative surrogates that are to serve as indicators that the firm is acting in a socially responsible manner in these diverse areas of its activities.

The Social Cost of Protecting the Environment

While this rubric may sound out of place considering the main thrust of this research project, the emphasis here is upon social cost at the macro or societal level. The research to be suggested in this section does not apply directly to business entities and is therefore substantially outside the main area of this paper. Discussions with engineers concerned with pollution problems of business firms indicate that what appears to be national policies may be in direct contradiction in terms of desirable and realistic levels of policy attainment.

Hendrickson discusses the power consumption of an electrostatic precipitator as collection efficiencies change. "The collection efficiency depends on the voltage level; but on the other hand the higher the voltage level, the greater the power drain. At 90 percent collection efficiency, the power consumption is approximately 0.2 kw/1,000 CFM (cubic feet per minute) of gas and at 99.9 percent efficiency, the power consumption has risen to approximately 0.8 kw/1,000 CFM."[15] It requires approximately 4 times as much power to attain the last 10 percent collection efficiency of these devices. Discussions with the mills engineer in charge of the electric power plant and the environmental engineer indicate that this sort of substantial increase in power requirements to reach the last incremental percentages of abatement facility efficiency levels is applicable to much of the new equipment acquired.

If the above situation is true, then research is needed to indicate the national fuel oil cost for reaching various incremental levels of pollution abatement with the possibility that only relatively small decreases in pollution standards could produce substantial fuel consumption savings at the national level.

In addition, communication of the research findings to the affected agencies would be necessary in hopes of developing environmental protection standards and fuel oil conservation policies that recognized the possible trade-offs that might be revealed by this type of research.

NOTES

1. Gaskell, William J., op. cit., 13 and 15.
2. Bradshaw, Thornton F., "The Corporation Executives' View of Social Responsibility," Financial Analysts Journal, September-October, 1971, 72.
3. Churchill, op. cit., 3.
4. Bradshaw, op. cit., 71.
5. Churchill, op. cit., 18.
6. Löf, G.O.G., W. M. Hearon and B. T. Bower. "Residuals Management in Pulp and Paper Manufacture," Bulletin from Resources for the Future, December, 1972, 17.
7. Allan, op. cit.
8. Andrews, op. cit., 1.
9. Ibid., 1.
10. Ibid., 1.
11. Ibid., 1.
12. Bauer, Raymond A. and Don H. Fenn, Jr., op. cit., 8.
13. Andrews, op. cit., 1.
14. Ibid., 1.
15. Hendrickson, op. cit., 5-5 and 5-6.

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Barker Dean Corbett was born September 27, 1931 in Hahira, Georgia. In June, 1949 he graduated from Carlisle Military School in Bamberg, South Carolina.

From June, 1949 until August, 1956 Mr. Corbett was employed as a retail clerk while attending Jacksonville Junior College, part-time. From August, 1956 until August, 1963 he was employed as manager of a retail drug store in Jacksonville, Florida. In August, 1964 he received the degree of Bachelor of Science with a major in Accounting from the University of Florida. From August, 1964 to September, 1968 Mr. Corbett was employed as a staff auditor with Haskins & Sells, Certified Public Accountants.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Delmas D. Ray, Chairman
Professor of Accounting

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Ralph H. Blodgett
Professor of Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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